# JOURNAL
## OF THE
# AMERICAN WATER WORKS ASSOCIATION

VOL. 33, NO. 10 OCTOBER, 1941



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## Special Rates and Free Water Service

*By Dale L. Maffitt*

THE granting of special rates and free water service is a controversial question. For years it has been a general practice for water companies to grant special rates to large consumers and to provide free water for public use.

At first thought it would seem that any business man would state freely that one never gets something for nothing. Yet it is the business man who usually desires a preferred rate. It may be the city council or the chamber of commerce that asks the rate as an inducement to persuade a large industry or factory to build in the city, or to prevent some industry from leaving the city. It is argued that the factory will provide labor and wages and purchasing power for citizens of the community. The fact that the rate is discriminatory in relation to other water consumers is disregarded.

It has long been the opinion of the majority that water for public use should be paid for from tax-collected revenue. It is the taxpaying public that gets the benefit of water used for fire protection, yet it is evident that the taxpaying public and the water-consuming public are not necessarily the same. Free water for public use is a fallacy. If the taxpayer does not pay the bill, the water consumer must. In spite of the fact that the majority opinion is against the furnishing of free water for public use, however, the number of cities

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A paper presented on June 26, 1941, at the Toronto Convention by Dale L. Maffitt, General Manager, Des Moines Water Works, Des Moines, Iowa.

furnishing free water continues to grow; and with the increase in Works Progress Administration projects promoted for public benefit the percentage of water used by public agencies has increased.

The depression period, starting in 1929–30, brought a decided increase in the demand for free water for public use. With the gradual improvement in business and in tax collections, other uses have been found by cities for these revenues and it is difficult for water boards to make collection again for public use of water. If this tendency continues there is danger that it may undo the progress that has been made in building up water works service to an independent and self-sufficient status. Taking an extreme view, it may tend to bring water boards back into politics to the extent that patronage and discrimination may work a definite hardship on the taxpayer and the water works management; and, further, may even result in lowering the quality of service to the water consumers.

Most cities have some system of sliding scale rates which are applicable to all classes of consumers. Large users, of course, get into the higher brackets of consumption and so obtain part of their water at lower rates, often below actual cost of pumpage and treatment.

## Extension of Special Rates

It has been a growing practice to extend special rates for such purposes as lawn sprinkling and air-conditioning. In the case of lawn sprinkling it is argued that the improvement in appearance of the city makes it desirable to encourage use of water on lawns. As a matter of fact it is doubtful if the saving involved makes much difference to the individual householder. If he takes pride in his lawn he will sprinkle it regardless of rate. Furthermore, excess use of water on lawns in a dry season may contribute to a dangerous shortage of water for general use.

The granting of special rates for use in air-conditioning, where the water can be metered separately, is usually justified as being the disposal of a surplus commodity at a reduced price, but it introduces difficulties usually accompanying surplus commodity disposal. The granting of special rates to any consumer will naturally tend to create a like demand from other consumers. A rate structure which is designed to carry a certain per cent of consumers at special rates is evidently unfair to those consumers who pay for services rendered at the prevailing rates.

There are a number of cities that grant free water for fire protection

and street flushing. They justify this action with the argument that since the city does not collect taxes from the water company, the water company must reciprocate by not charging the city for water for public use. The fallacy of this conclusion lies in the fact that there is a distinction between the taxpayer and the water user. Granting of free water to the city for public use gives the taxpayer a benefit at the expense of the water user.

### Inconsistency in Special Rates

Responses to inquiries sent to various representative cities show that there is no consistent policy in regard to special rates and free water service. The various letters received by the author evidence many interesting situations.

L. S. Vance, Chief Engineer and Superintendent of the Louisville Water Co., Louisville, Ky., states:

"'Free service' for municipal functions is a statutory provision of our municipally owned private water company. It will be 'with us' until the laws are changed. Unfortunately, any attempt at changing such statutes is hazardous in present-day legislatures, so no such change is contemplated. . . . We have dreamed of the time when a cash allocation in the amount of normal water bills for each department of the city could be made by our company to each city department, and then actually bill that department for all water used at the regular rates. Leaks, waste, and wasteful use would then be corrected. And the actual contribution by the company for the 'free service' would be segregated in a 'below the line' charge and borne by the stockholders (taxpayers) rather than by the rate payers (water users) which is what occurs now when the cost of such 'free service' is lost in operating expenses.

"Special rates in water departments for special uses are not, in my opinion, generally to be desired. It would, of course, be desirable under some circumstances to better the average plant 'load factor' in attempts to eliminate peaks of demand and thereby postpone otherwise necessary increases in plant capacities. Off-peak sprinkling rates when applied with the use of recording register meters might be one safe way of accomplishing this, as demonstrated in St. Louis County. However, I can't at present visualize any other reasonable application of special rates for special uses."

W. F. McMurry, Superintendent of the Water Department of the City of Tulsa, Okla., writes that Tulsa established a sliding scale rate

schedule about six years ago. Exceptions to the schedule are that governmental properties and churches receive a flat 10-cent rate and consumers outside the city pay 50 per cent additional until they have used 250,000 gallons. There is a summer sprinkling rate whereby residential properties in the city pay only 10 cents per thousand gallons for the water they use above their winter average. Outside the city, residential properties pay 50 per cent higher, or 15 cents per thousand gallons, for this excess water. The city's divisions, such as street cleaning, parks, and sewage disposal plant, are furnished water without charge. No charge is made for fire protection stand-by service.

Mr. McMurry believes personally that the summer sprinkling rate should be abandoned. This, however, would mean a revision of the existing rate of 35 cents per thousand gallons for the first 15,000 gallons. He does not object to the 10-cent rate for governmental properties, but feels that some charge should be made for water used by city units. He thinks that all fire service lines should be metered and that the minimum charge for such meters should be placed on this service.

## All Pay in Duluth

The late Felix Seligman, Manager of the Water, Gas & Sewage Disposal Dept. of the City of Duluth, Minn., felt that an important factor in the development of a sound rate structure is an accounting system which records accurately the uses for which all water is pumped, as well as the cost of the service rendered. He stated that the water department of Duluth had been no exception to the rule in that it had considerable difficulty in obtaining payment from the city for fire protection service. For a period of years no payment was made. At the present time the city is paying for fire protection service, and has no free water service or special rates to any consumer, including the city, churches, schools, etc. All consumers are charged in accordance with the rate structure.

H. H. Hyman, Vice-President of the Miami Water Co., Miami, Fla., states that his company has no special rates. Every customer pays the same rate for his respective service. He feels that the granting of free fire protection and free water by a water company to a municipality is very much misused and out of order, and that it places an unfair burden either upon the taxpayers or the water consumers.

Until recently the Miami Water Co. furnished the City of Miami

free water service for fire protection, flushing of streets and flushing of sewers. To offset this franchise provision, the city did not assess the company taxes on personal property. This worked greatly to the advantage of the city when it was small, but, due to the great growth of Miami, the city has perhaps been at a slight disadvantage for the last ten years. The situation at the present time is that the company receives $30 per year, per fire hydrant, but nothing for the flushing of streets and sewers. Likewise the company pays taxes on personal property. The rate of $30 per hydrant is too low for the service, which naturally penalizes the water consumers. After considerable litigation, however, and because of the fact that the city will no doubt acquire the property of the company in the near future, the rate was not contested further. The Miami Water Co. owns only the distribution system in Miami, the producing plant having been the property of the city since the time treated water was first supplied to the water users.

## State Law in Iowa

John W. Pray, Water Works Superintendent of Fort Dodge, Iowa, calls attention to the fact that the Iowa law provides protection for the water departments (Chap. 313, Sec. 6184), which prohibits the granting of special rates or free water service. It is necessary, under the Iowa law, to apply the same rate to all consumers.

In connection with fire protection, Mr. Pray states: "We feel that a sprinkler-protected property is also a benefit to the water department. Surely a fire in such a property will be put out with much less water than would be used through a fire plug, and, in many cases, a fire stopped quickly might have developed into a large one using many thousands of gallons of water. So, we make no charge for fire protection, regardless of the type of service."

He further states that in addition to the fire protection problem, his department is compelled to transfer large sums each year to the general fund, which is an additional burden on the water consumer.

J. L. Hawkins, Superintendent of the Greenville City Water Works, Greenville, S. C., writes:

"It is our opinion that everyone should contribute toward the upkeep of public services and institutions even though they do so in a very small way, and for that reason about two years ago we ceased to charge the city for these services, inasmuch as payment for them was taken from the taxpayer.

"It is our observation that water customers are given a better

break through reduced rates, if possible, than is given to taxpayers. In other words, almost every water department is striving to render better service at cheaper rates, whereas taxes are seldom reduced.

"There is another condition that prevails in and around our city. The city owns and operates parks, libraries, hospitals, and various and sundry other services that are enjoyed by some forty thousand people living just outside the city limits. This department sells water to the suburbs as well as to those inside the city, and by our furnishing these services free inside the city those people from the outside are contributing in a small way toward the upkeep of the city services they are enjoying."

### Two Schools of Thought

A. G. Moffat, Secretary of the Sewerage and Water Board of New Orleans, La., calls attention to the fact that there are two distinct schools of thought as to whether or not a municipal water works should provide free water or reduced rates:

1. From a strictly scientific (or we might say idealistic) viewpoint, it is held that a municipal water works should be conducted precisely the same as a private one; i.e., that all consumers should be required to pay for water used at regularly adopted rates, and that all public departments using water should pay for it out of their operating incomes.

2. Others believe that the furnishing of water is essentially and primarily a governmental function; that when a municipality establishes a water works system, it does so primarily to provide fire protection, as an aid to sanitation, and for public enjoyment; that the selling of water is only an incidental and secondary function which should be paid for only by those who use water for domestic or industrial purposes; and that water for all public, charitable, or other general purposes should not be directly charged for, but the cost should be absorbed by the water works, which in the final analysis means by the paying consumers.

Mr. Moffat thinks that the problems of New Orleans should be of special interest in this connection because probably a greater percentage of free water is furnished there than in any other American city. In 1940, for instance, the City of New Orleans, which has an all-meter system, purified and pumped 22,727,700,000 gallons of water. Of this amount, 55 per cent was sold; 8.5 per cent was furnished to various public and charitable consumers who under the law

are entitled to free water; 6 per cent was allowed free to regular pay consumers for flushing toilets; 3 per cent was allowed to pay consumers to cover water wasted through burst pipes, leaks in plumbing, and other causes beyond their control; 27.5 per cent was unaccounted for, and represents uses at the water plant, under-registration of meters, leaks in the distribution system, and unmetered water used by various city departments through fire hydrants for extinguishing fires, cleaning streets, flushing sewers, drains, etc.

In explaining the enactment of the present laws in connection with the New Orleans system, Mr. Moffat gives a brief history of the water works in that city. Its early problems add a touch of human interest:

"Prior to 1908 we had no purification plant, no public water works, and no sewerage system. Up to that time our domestic water supply was accumulated in cisterns, which were cypress tanks holding 2,000 to 3,000 gallons, located at the rear of the houses and connected to the roofs by metal pipes. The rain falling on the roofs at intervals filled, or partly filled, the cisterns, carrying into them with the rain deposits of dust, dirt, birdlime, dead birds, mice, and various other juicy morsels. The people of New Orleans never knew what it was to have a sufficient amount of water for bathing or other domestic purposes. Consequently the Saturday night bath was a sacred rite requiring very little water; and we economized to the last degree in all of our domestic uses, but we managed to get along somehow despite periodic outbreaks of typhoid, yellow fever, malaria, dysentery, and sundry other ailments caused by lack of sanitation and an impure water supply.

"A plan was finally developed to levy taxes to improve the drainage system and construct a modern sewerage system, water purification plant and distribution system; and when the proposal came up before the state legislature for action, there were many interests that had to be appeased. When the law was adopted it contained provisions requiring that free water be given to many institutions that should rightly have paid for it. This included all municipal departments, public schools, orphan asylums, charitable institutions, and all hospitals existing at the time, and made the unusual provision that free water should be furnished to all consumers 'for sewerage purposes.'"

Mr. Moffat concludes: "If the city government had to pay for all the water that is consumed in its various departments, it would have to raise the rate of taxation, which would put the entire burden

of furnishing water to public and charitable institutions on the property owners. As the owners of taxable property in any community do not represent a very high percentage of the total population, the burden of supplying water to all the city's public institutions would have to be borne by a comparatively few individuals, whereas under our plan the cost of supplying water to the city's various public departments, the benefits of which are shared by the entire population, is borne by the paying consumers, and is, therefore, justly distributed over a much greater percentage of the population than if it had to be borne entirely by the property taxpayers. Any upheaval in a water department, which is satisfactorily functioning, in order to transfer the burden of water used for public purposes from the water rate payer to the property taxpayer does not seem justified, and the writer is inclined to agree with the fellow who said it would 'just be taking money out of one pocket and putting it in another.'"

## Charges in Denver

D. D. Gross, Chief Engineer, Board of Water Commissioners, Denver, Colo., writes:

"We believe there is no reason why the water department should be called upon to make donations to any other city department or any public or private institution. We believe that the water department is entitled to receive compensation for all service which it renders, both public and private, and in justice to the water consumer, this should be the case. It is not fair that the water department should collect money from one body of citizens and make donations to another and perhaps different body of citizens. While citizens must of necessity use water and directly or indirectly must pay for it, the benefits which they may derive from public schools, parks, streets, and other city departments may not be, and in fact seldom are, in the same ratio as the bill they pay for water. We believe that the benefits which they derive from the activities of other departments of the city government are more correctly reflected in their taxes than in their water bills.

"If payment is not received for all water delivered, and the funds received administered to maintain an efficient plant and personnel, the chances are good that the plant is not economically operated and in the end the consumer is not receiving good service and is paying more for water than he should. The water department should receive full payment for all service it renders. Service received free is not

appreciated and usually little thought is given to economical use of free water. In short, free water leads to waste.

"The Denver Water Department is required to pay its own way. It is administered by an independent board, and all funds are kept separate. All the expenses of bond retirement, interest on bond indebtedness, capital investments, maintenance, and operation are paid from revenues received. The city pays fire hydrant rental into the water department fund, in cash; the amount of payment is regulated by a charter provision, adopted at the time the city purchased the water plant, the rental ($22.50 per annum) being considerably less than the actual cost of the service. No additional payments are made for sewer flushing or street sprinkling. Water used in the parks, and so forth is supplied to the city at a rate also limited by a charter provision, and is slightly less than the charge made to private consumers.

"The water department pays no taxes. However, it pays other city departments for services rendered. If all services were evaluated, including taxes, the city would owe the water department a considerable sum of money each year."

In Des Moines, Iowa, all water is metered and the city of Des Moines pays a specified amount for the public use of water and for fire protection. The amount is agreed upon by the city officials and the Board of Water Works Trustees. In the year 1940, 77.38 per cent of the total water pumped was billed to private consumers.

### Free Water and Water Revenue Bonds

W. F. Tempest, of the A.W.W.A. Committee on Joint Administration and Collection of Water and Sewer Accounts, suggests that his concern is that the tendency, if there is such, to have water works considered as a governmental function may lower the respect for water revenue bonds and impair future financing of water works. He does not believe, however, that very many municipalities will be shortsighted enough to let this matter of free water progress to such a point.

Mr. Tempest also calls attention to the Ohio Supreme Court decision ruling that Cleveland hospitals, churches, schools, and cemeteries are entitled to receive free water under a municipal ordinance. There are some 450 institutions in Cleveland which each year receive approximately $150,000 worth of water free of charge.

## The System in Los Angeles

An article appearing in the *American City* for March, 1941, tells how the city of Los Angeles, where it is illegal to sell water at rates below those established by ordinance, continues its policy of granting free or part free water to charitable institutions. Under the city charter the board of water and power commissioners may transfer to the city general fund surplus revenues of the water and power bureaus. The board cannot earmark such funds for specific purposes, but there can be a tacit understanding that, after transfer, they will be used for the purposes originally intended. This simple expedient has made it possible for different boards to transfer substantial sums of money to be allocated by the city council to the social service commission, which subsequently returns to the department of water and power a portion of that money in payment for the free water and electricity granted to charitable institutions. Under this procedure, the department, in a roundabout way, pays itself for the services supplied in the name of charity, and yet adheres strictly to the rate ordinances, and complies with the letter of the city charter.

This policy of granting free water to charitable institutions had its beginning early in Los Angeles history. From 1902 to 1938 charitable institutions received an 85 per cent discount on water bills. In May 1938, the board of water and power commissioners discovered that the charitable institutions were getting their water at 20 per cent below actual cost. As a result of this disclosure the whole subject of charity discounts was reviewed again, with the resulting recommendation that beginning November 1, 1939, the maximum discount for water and electricity each be fixed at 50 per cent for organizations 100 per cent charitable, the discount to decrease in direct ratio to decreased percentage of charitable services performed.

The object of this article in the *American City* was to call attention to the fact that through the expedient of "transfers of water and power revenue funds to the general and reserve funds of the city" substantial water board sums are being applied annually in part payment of water and electricity bills rendered to charitable institutions.

These diverse experiences and conclusions make it clear that the "problem of free water" is not one that can be easily solved. Rather, the various opinions and supporting arguments seem to add to the confusion; but if the problem is to be worked out at all it would seem that the open and free expression of arguments for and against is the first step toward a satisfactory solution.

It should be remembered that our first responsibility is the furnishing of satisfactory service to consumers in the most economical way possible. This means that a water works must of necessity have a large investment in equipment and water mains, in order to insure an adequate and wholesome water supply for the entire community at all times. Extreme drought, conflagration, or otherwise abnormally increased consumption are possibilities that must always be kept in mind by the water works engineer; and an adequate source of supply must be maintained to meet such an emergency, should it arise. In our discussion of special rates and free water these primary responsibilities must be kept in the foreground.

## Special Rates for Federal Housing Developments

*By Hal F. Smith*

THE title of this paper implies that its author has had considerable experience with federal housing developments. This is not the case. His personal contact in the field has been limited to dealings with a local housing commission. While this experience has been pleasant, agreeable, and satisfactory in every respect, it has, nevertheless, indicated that housing officials have a concept of their relationship to public utilities that is not in complete agreement with that held by the utilities.

Inquiries indicated that Detroit was not the only city in which this difference of opinion existed. The fact that we are all so vitally interested in promoting a national unity of purpose in all things is probably the reason why the A.W.W.A. headquarters staff evidenced some concern over a situation, which seemed to be developing in some sections of the country, that indicated a lack of 100 per cent unified effort between the water supply industry and certain local housing commissions.

It is the purpose of this paper to report the result of the author's attempt to determine whether or not the alleged condition does exist and, if it does, the extent to which it exists, and the reasons therefor. Time did not permit a thorough canvass of the field, but a number of inquiries disclosed the fact that there was a feeling, in some quarters at least, that local housing commissions were requesting or demanding special privileges from their municipal water departments or local operating water companies and, further, that this situation was not limited to water supply, but apparently applied with equal force to other public utilities, such as gas and electric companies.

Inasmuch as it was evident that such disagreement as does exist

A paper presented on June 24, 1941, at the Toronto Convention by Hal F. Smith, Senior Administrative Assistant, Department of Water Supply, Detroit, Mich.

centers about the question of special privileges, it seemed advisable to ascertain whether such requests originated in the minds of the local housing commissions, or whether they were directed by the central headquarters of the housing admistration. To this end, the author had a very frank discussion with Nathan Straus, Administrator of the United States Housing Authority (U.S.H.A.), and submitted to him the following three questions:

1. What is the present status of the U.S.H.A. program?
2. Does the U.S.H.A. expect special rates and concessions from public utilities?
3. What more can the water industry do than it is doing to co-operate with the U.S.H.A.?

Mr. Straus answered these questions fully and frankly and expressed his appreciation for the opportunity to acquaint the members of the A.W.W.A. with U.S.H.A. point of view on the questions submitted.

Concerning the present status of the U.S.H.A. program, Mr. Straus reported that there are now 544 housing projects under loan contract, 383 of which are now occupied or under construction; that federal housing projects are now under construction in 37 states and territories of the United States; that the 544 projects under loan contract represent 165,605 units, of which 127,748 are already completed or under construction. He also stated that the average water consumption per dwelling unit for the U.S.H.A. projects now in operation is 175 gallons per day. These figures are given simply to point out the tremendous extent of the U.S.H.A. activities and the extent of the field in which it is now operating.

## Reply of U.S.H.A. Administrator

Regarding U.S.H.A.'s expectations of special rates and concessions from public utilities, Mr. Straus replied:

"The answer to this question is 'Yes'—where existing available rates and conditions of service are such that their application to the slum-clearance projects would work against the achievement of the aims of the public housing program, as enunciated in the United States Housing Act of 1937 and in the various state housing acts. In order that the aims of the program may be achieved, it is necessary above all to achieve rent-plus utility charges that can be afforded by the low income families for whom these projects are designed. The U.S.H.A. and the local communities do all in their power, including the granting of subsidies in the form of funds and services, to obtain

low shelter rentals. Since the total cost of housing to the tenant always includes many utility services, the cost of these latter also must be kept to a minimum. The utilities and the public service commissions in general, recognizing this problem, have granted and approved special rates and concessions (always making sure that these are compensatory to the utility) in those cases where achievement of a successful public housing program is at stake."

In pointing out what more the water industry can do to cooperate with the U.S.H.A., Mr. Straus said:

"On the whole, the U.S.H.A. feels that the water industry has understood the problems involved in constructing and operating housing projects for very low income families. With few exceptions, the private companies and municipalities have made available reasonably low rates for service to the projects through master meters.

"One of the most desirable improvements in our relation with the water industry would be conformity on the part of the few uncooperative private and municipal water companies to the generally reasonable attitude of the industry as a whole. Of particular concern to U.S.H.A. are those municipal water utilities which, contrary to the general practice, refuse to extend to slum-clearance projects water rates that have been made available to hospitals, schools or other municipal or charitable institutions. In view of the value of these projects to the city, it is felt that the municipal or charitable rates already in existence should certainly be granted to the local housing authorities for their projects.

"Aside from the question of rates, I would also like to make a concrete suggestion regarding a technical contribution that might well be made by the water industry.

"There is a definite lack of test data on the subject of the peak load, or 'maximum momentary demand,' for which housing project water systems should be designed. (Reference is made obviously to domestic water supply only, since the requirements for fire flow are well established.) The cost of water distribution systems in housing projects runs, in the aggregate, into hundreds of thousands of dollars and the systems obviously should be designed on a basis that will insure adequate service during the life of the project, without extravagant over-sizing.

"The technical staff of the U.S.H.A. has developed some tentative recommendations on rates of flow for serving varying numbers of dwelling units, but these recommendations have perforce been prepared without reference to the results of comprehensive tests. If a com-

mittee of the American Water Works Association could undertake a study along this line and develop a well-founded basis of design, it would be doing a service which, we believe, would be of value not only to housing agencies but to the entire engineering profession."

Regardless of what our own opinion may be on the points discussed by Mr. Straus, we will all agree that we owe him a debt of gratitude for his frank, sincere, clear-cut answers to the questions submitted. He has clarified the picture. We now know, without any possible doubt, that the U.S.H.A. *does* expect special rates and special privileges from public utilities.

The question as to what extent (if at all) special rates and concessions should be granted is beyond the scope of this paper, but in an attempt to secure some data that may be helpful to the Association and/or its individual members in formulating a policy on this question, the author sent a copy of Mr. Straus's statement to the American Gas Association, the Edison Electric Institute, and the Municipal Finance Officers Association, with requests for their comments on the subject.

### Relations With Gas and Electric Utilities

We are indebted to Alexander Forward, Managing Director of the American Gas Association, for his prompt reply and for his permission to quote all or any part of his letter. Mr. Forward said:

"The American Gas Association has enjoyed excellent relations with the United States Housing Authority and its predecessor organizations, and I think it is a fair statement that the gas industry has benefited by the substantial sale of gas to the United States Housing Authority projects. In many cases, these projects were erected in city districts in which there had not previously been as high a saturation of gas appliances, and in other instances, which are arising from the defense program, wholly new customers are being added to the gas lines.

"From the very inception of housing work by the U. S. Government, the American Gas Association has tried to work closely with the Departments in Washington responsible for the various phases of the program. Our Washington representative was in a position to furnish Government officials with information on available gas supplies and rates promptly, and our engineering staff has co-operated with Housing Authority in the formulation of basic factors for the selection and evaluation of fuels and equipment.

"One of the important problems which the gas companies had to face from the start of the housing program was the request of the

United States Housing Authority for gas service at prices enabling them to keep the overall cost of rent plus utility charges within the income levels of the families for whom the projects were being planned. In most cases, the available gas company rates were adequate to meet the situation. In some instances, the objectives desired by the United States Housing Authority were achieved by the purchase of of all gas through a single master meter, thus enabling the project to purchase gas at the wholesale prices.

"One interesting development which helped the gas industry to secure the gas load and also materially helped the United States Housing Authority to offer low rents was the reduction in appliance maintenance and service costs made possible by the large scale of the operations. For example, the estimates of cost of servicing a gas range were found to be high and, in most instances, the utility companies were able to arrange for such work at considerably lower charges which, in turn, brought the rent plus utility cost to satisfactory levels."

A statement by C. E. Greenwood, Commercial Director of the Edison Electric Institute, with the exception of a few paragraphs which do not deal directly with the question at hand, is quoted verbatim, as follows:

"As a general statement in connection with the "co-operative" attitude, suffice it to say that we had a representative who contacted the U.S.H.A. office in Washington from time to time, and attempted to interpret the thinking and desires of the Administration to the utility companies. They were advised where these projects were to be built as far in advance as possible, and were urged to consult the local authorities as to their requirements. In relation to equipment, it was not so difficult to sell refrigerators which required no additional copper capacity, but on the matter of electric cooking versus gas, there were involved additional wiring costs, higher equipment costs, and then the all-important matter of rates for the service.

"There were certain manufacturers who quoted attractive prices for ranges and refrigerators, which if the rate and other local conditions were acceptable to U.S.H.A., influenced the projects to have all-electric equipment.

"However, some of the electric utility companies have felt that decisions at Washington were made often on the basis of political rather than economic considerations.

"To be specific on this question of co-operation one must get down to the question of the interpretation of that word. Certain companies

were understood "not to co-operate" when they would not make certain concessions in the building and maintenance of service within the property lines, or maintain the utilization equipment, or who were not interested in having electric cooking installed under conditions stipulated. Incidentally, I would emphasize that comments on the co-operative action of utilities have been made by engineers and staff officers below the top executives of U.S.H.A.

"Now from the earliest negotiations, the opinion of Mr. Straus has guided his staff procedure. We were told that these were projects for local civic betterment and that the utilities should be ready to offer a "social" rate if necessary to "co-operate" with the Housing Authority. There were a few instances where special rate concessions were made with the approval of the State Commissions, and there are instances of a municipal rate being applied for this wholesale service. Many companies did not favor such concessions which at times would mean direct loss to the company. Others believed that the rate offered for cooking, if economically sound for other customers, should be satisfactory for slum clearance projects."

"In summing up, I would express the opinion that utilities had co-operated with the U.S.H.A. on all reasonable requests, and some had tried to see eye to eye with the Housing Authorities to the point of stretching both the reasonable and the economic factors. As a general rule, if one wants the business of U.S.H.A., concessions must be made somewhere along the line.

". . . I will not send a statement which could be quoted as representing the national policy of our Association. There is none on this subject. We obtain facts, and have not tried to influence local determination on what they do with these. We consider the exceptions to be made in local operating policy a local problem."

Carl H. Chatters, Executive Director of the Municipal Finance Officers Association, offers the following comment:

"You have asked about my opinion on the subject of special utility rates to government housing projects. My answer is simple and you may quote it anywhere you wish. It is my own personal opinion. There is, in my opinion, no justification whatsoever for charging government housing projects any different rate than you would any other type of institution for similar quantities of water. The question of subsidies and exemptions is one of the most aggravating problems we have in government today, and the sooner we wipe out all special privileges and exemptions of any type whatsoever, the better off government will be."

## Opinion of Attorney

Before further considering the U.S.H.A. point of view, it seemed advisable to inquire into the legal aspects of the case. An opinion on this matter was asked of James H. Lee, who has served the City of Detroit as an attorney for the past 29 years, the last 10 of which he has devoted almost entirely to public utility matters, representing the city in hearings before the Michigan Public Service Commission, the courts, and Federal agencies in Washington. His statement was as follows:

"It appears that the controversy presented by the issue as to whether special rates and conditions of service should be accorded by public utility corporations to housing authorities, divides itself into two parts: (1) the matter of policy involved; and (2) the legality of special public utility regulations and rate schedules. I am confining my discussion to the legal phases of this matter.

"It is well settled rule of law that 'public utilities, as a condition to their enjoyment of franchises which tend to be monopolistic, must serve all consumers equally, and without discrimination. Nevertheless, the Courts have consistently recognized that this requirement of uniformity (rates and service regulations) extends only to members of like or similar classes. A classification of consumers based upon reasonable differences in facts and circumstances results in no unlawful discrimination.' Therefore, the issue presented is: Is there factual justification for the classification of public utility rates and service regulations accorded to Federal Housing Projects? I am of the opinion there is, and for that reason there is no discrimination against general users of such utility services and no unreasonable preference given to such housing projects.

"What is reasonable or unreasonable, as in all other branches of the law is determined in utility law by an examination of the facts. (Illinois Central R.R. *v.* I.C.C. 206 U.S. 441, 51 Sup. Ct. 1128 (1907); Griffin *v* Goldsboro Water Company, *Supra*; New York Te. Co. *v* Siegel Cooper Co., 202 N. Y. 502, 96 N. E. 109 (1911); City of Superior *v* Douglas County Tel. Co., 141 Wis. 363, 122 N. W. 1023 (1909); Happy Hollow Golf *v* Nebr. Pr. Co. (N. B)., P.U.R. 1928-D 254.)

"Let us first consider the facts which justify a special rate and service classification:

"1. The Federal Housing Authority is a public non-profit corporation, devoted to a public use, to-wit, the elimination of slums and the creation of low rental housing projects.

"2. Decisions of the supreme courts of many states, including our own State of Michigan (*291* Mich., *313*) have sustained the validity of this housing legislation.

"3. Municipalities have granted the housing authorities exemption from local taxation, and in lieu thereof have entered into service charge contracts. This amounts to a subsidy contributed by the local community to the housing project. Without such subsidy, the purpose of the project, to-wit, the housing of low rental income families, could not be achieved.

"4. The granting by the public utilities of a special rate schedule, together with the tax exemption referred to, makes possible the reduced rentals to be paid by the occupants of such housing projects.

"So much for the general facts which constitute a basis for special classification. Now for the specific facts which justify such classification:

"1. Such special rate schedules provide for the taking of the different utility service at one point on the housing project through a master meter. It is obvious that this reduces the costs of such service where there would be many meters.

"2. The occupants of these housing projects are limited to those within a certain income bracket, and the rentals they pay to the housing authority include the cost to them of heat, light, water and cooking fuel, which is paid by them in their rentals; and the cost of utility services to the individual tenants of the housing projects is prorated on the basis of the total estimated annual costs of these services for all of the dwelling units, with the result that the individual tenant's reasonable use of such services will not be restricted by the prospect of an increased bill at the end of the month.

"Thus it is evident that the credit risk to the public utility corporation in serving slum clearance or low rental housing projects is of no importance since the utility is paid by the housing authority and the revenues of such authority are derived from the rentals of the tenants and in addition the contributions received from the United States Housing Authority. Thus loss of rentals because of nonoccupancy or failure of tenants to pay rents in no way jeopardizes the payment of the utility's bills. Again it is obvious that this lack of credit risk and any costs of collection reduces the utility company's costs.

"The credit of the local Housing Authority is substituted for the credit of the individual tenants. The courts have held that such decrease in costs to the utility companies is a sufficient reason for

decreasing rates. (Williams *v.* Marysville Tel. Co. 119 Ky. 33, 82 S.W.995, (1904); Souther *v.* City of Gloucester, 187 Mass. 552.).

"Also, the Courts have held that such reduced costs because of special conditions involved in services to special classes, constitute a factual basis for special rate schedules which do not result in unlawful discrimination against general users. (Western Union Tel. Co. *v.* Call Publishing Co., 44 Nebr. 326, 62 N.W.506, 181 U. S. 92 (1901); *In Re* Wholesale Rates for Electric Power to Rural Co-operative Associations 19 P.U.R. (N. S.) 22, (1937); McQUILLAN on *Municipal Corporations* (2nd Edition, 1928) Vol. 4, Sec. 1829 et seq.).

"There is abundant precedent in the orders of the state public utility regulatory boards and in the court decisions, for the legal justification for special rate schedules to housing projects. Many such special schedules have been approved where the service is given by a privately owned utility as well as a publicly owned utility. Such reduced schedules are a necessary factor in order to achieve the low rental rates, which could not be achieved in the first place but for the subsidies received from the Federal Government and from the state and local governments in the form of tax exemptions.

"Where the utility involved is municipally owned, the management thereof may have the idea that if such utility is to give special reduced rates to housing projects, then the utility should be reimbursed for any reduced income out of tax bonuses from the community which owns the utility. It is my opinion that such an idea is unjustified. The community has already made its contribution by tax exemption of the housing project. Even though the special rate schedule is less than the general schedule, the courts have held that the returns thereunder must be compensatory to the utility; in other words, that the service need not be given at a loss even though it is given at a reduced rate.

"In conclusion, I wish to reaffirm my opinion that the granting of such special concessions in the way of reduced utility rate schedules and conditions of service to a public housing project has the weight of overwhelming legal precedent."

Regardless of the question of the legality of granting special rates and privileges to Federal Housing Projects, there is still the question as to whether such practice is in accord with good business principles. Unquestionably, there are many who are opposed to special rates for any groups, including public schools, municipalities, hospitals and charitable institutions. What, if any, further study or action should

be undertaken by the Association on the question of special rates and privileges to Federal Housing Projects and on the question of developing additional data on the "maximum momentary demand," for which housing project water systems should be designed, as suggested by Mr. Straus, is another subject worthy of discussion.

**Discussion by *L. G. Lenhardt:**** Housing authorities should take advantage of sliding scales of rates where such are in force. This is merely the exercise of group purchasing power and should be used wherever possible. Housing authorities should not, however, expect subsidies from water departments or other utilities to finance current expenses. These are hidden subsidies. If subsidies are necessary they should be frankly recognized as such and paid for accordingly.

Most water supplies and many of the other utilities of this country are municipally owned. Theoretically at least these are supposed to render service at cost. Therefore, any cut in rate for the benefit of a housing project would mean service below cost. In other words, the housing project would be given a hidden subsidy by the utility rate-payers of municipal utilities. To a large extent this, of course, is also true of privately owned public utilities.

The U.S.H.A. cites the fact that hospitals, as a rule, are subsidized by lower rates. There is this essential difference—a hospital is recognized as for the benefit of the entire community and hospitals, as such, are seldom if ever self-supporting. They usually are at least a semi-charitable institution and take care of those emergencies which few of our citizens are economically able to withstand. The U.S.H.A. projects are normally not designed to cover the lowest economic brackets, such as indigents and those on the welfare, but are designed to furnish a better grade of housing for those below the average in the economic brackets, but who are still able to pay a satisfactory rental. As such they fill a praiseworthy function, but, to the writer, there seems to be no reason why they cannot and should not pay regular rates for the utilities they use. It seems that to give preferential rates to this type of housing development is not only unsound financing, but is discrimination against those in similar circumstances who are buying their home or paying rental to a private landlord.

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# Finance and Accounting of Denver's Water System

*By George F. Hughes*

THE Denver Municipal Water Works system was purchased from a private corporation in 1918, and its operation placed in the hands of a non-partisan board of water commissioners, with absolute power to operate the system without interference from any political source. There are five members of the Board, appointed by the Mayor for overlapping terms of six years so that a majority of the Board is always familiar with the operation of the plant. Two of the present members have served twelve years; one, eight years; one, six years; and one, two years. Mayors who serve more than one four-year term, of course, have the opportunity of appointing a majority of the members.

Since the plant was acquired in 1918, the several members appointed on the Board have been men of proved ability in their own fields, who have not previously held any political office. The Commissioners receive $50 per month and must attend the two regular meetings each month. If a Commissioner is absent from meetings for any reason other than department business, no compensation is paid him for that particular meeting, and if he is absent from three successive meetings for reasons not pertaining to water department business, he loses his post as Commissioner, unless absence from the meetings is because of illness or other unavoidable reason, as determined by the Board.

Agenda containing detailed information of all items submitted for consideration at board meetings are furnished each member on the day preceding the meeting so he may familiarize himself with all questions to be presented. Items of expenditures exceeding $1,000 require approval of the Board.

The Board has and exercises all the powers of the City and County

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of Denver granted by the constitution and laws of the State of Colorado and the City Charter in the matter of operating a water works system. It has the power to execute contracts and to institute and defend all litigation affecting its powers and duties. The Board has power to hire all employees as well as skilled and technical help, and to fix their compensation. The Board has the power to fix the rates at which water is furnished for all purposes, but these rates must not be more than necessary to cover the cost of bond issues, operation, maintenance, additions, extensions, and betterments. All funds not spent or contracted for at the end of the year are automatically placed in the bond sinking fund account.

In accordance with the Charter, the City and County of Denver must annually pay the Water Department for water supplied for all public purposes. Revenue of the Water Department is deposited daily with the Treasurer of the City and County of Denver, who places it in a separate account for the Water Department. Funds are paid out of this account only upon the warrants of the Board on audit by the Auditor of the City and County of Denver, except as to the bonds and interest thereon which the City Treasurer pays without such warrant or audit. The monies of the Water Department cannot be used for any purpose other than for the management, operation and maintenance, and for additions and betterments to the water works plant. No money can be expended from the revenues for additions and improvements in any year until provision has been made for the expense of operation and maintenance and interest on bonds for that year.

### Additions and Improvements to Plant

Since the water plant was purchased by the city in 1918, the Board has made many improvements and additions to the plant. This program of expansion has been supported by the citizens who have demanded that the city be furnished with an ample supply of water.

Since 1923, bonds for betterments and improvements have been issued in the amount of $12,649,600, which, together with the $13,924,000 floated for the original purchase of the plant, make a total of $26,573,600 of bonds issued. In addition to making interest payments, the Board has redeemed $3,560,000 of these bonds from earnings.

Besides the amount raised by bond issues, the department has spent $15,360,469 out of earnings for capital outlay. These large

expenditures were essential because of the run-down condition of the plant when it was purchased and also because of the necessity of going so far, 70 miles to the western slope of the Continental Divide, to secure an additional supply of water for the growing city.*

The present valuation of the water plant is approximately $42,000,000—a high valuation for a city of 322,000 population. This large investment is due primarily to the difficulties encountered in securing water, but another factor is the necessity to carry peak loads for lawn sprinkling during the summer season, when an average of 150 m.g.d. of filtered water are used. This latter factor has, of course, made necessary a larger plant than otherwise would be required.

To take care of the retirements and interest payments on bonds issued, a debt service program has been adopted. This program provides for the payment of interest and principal on the bonds at maturity dates which extend over a period until 1972. The top load that must be provided from revenues under the present debt program will occur in 1944, when interest and retirements will amount to $1,506,290, 50 per cent of present annual revenue.

## Reports and Budget

A monthly operating report, including items such as leak repairs, fire hydrants inspected, cash statement, number of employees (monthly and per diem), total amount of payroll, work orders issued, itemized expenditures of over $1,000, valve and stop-box inspections, rate inspection, turn-offs and turn-ons, charity cases, chemical laboratory examinations, watershed inspections, cost of electricity at pumping stations, etc., record of new taps and meters installed, and a chart showing location of new taps, is prepared for members of the Board.

At the end of each year, a detailed annual budget, which shows anticipated revenues and expenditures, is also issued. Monthly itemized statements showing the status of the budget are distributed to the several division heads. This statement gives separate figures on operation and maintenance, capital outlay, equipment, and unusual maintenance items. In other words, the budget statement is a watch-dog of expenditures. It also includes estimated revenues by

* This project, which cost about $12,000,000, involved the diversion of water from the western slope of the Continental Divide through a six-mile tunnel, at an altitude of 9,000 ft.—5,000 ft. under the Divide.

months during the year which is, of course, very essential in order to anticipate bank balances. In this way, the division heads are able to tell at a glance whether they are under or over their budget allowance. In addition to this annual budget, a five-year budget program, the purpose of which is to inform the members of the Board of necessary additions and improvements to the plant and to forestall a possible request from groups of citizens to secure a reduction in rates due to increased revenues, is used as a working schedule.

In the collection division, the punch-card method of preparing customer bills is used. It is a very simple operation to set up a permanent record of the customer's account on the punch-card, which is readily changed whenever desired. The cards are fed into a machine at the rate of one hundred per minute and the machine issues a printed bill containing items charged, credits, and arrears, with automatic totals of all accounts for control purposes. Billing of accounts for water rent are made quarterly on a monthly staggered basis and the accounts are due and payable in advance. Less than 0.5 per cent are delinquent at the end of the quarterly periods.

At the present time there are more than 78,000 services, of which only 3 per cent are metered. A card ledger system is used, each division clerk handling approximately 12,000 accounts. A cash register system is employed for posting purposes, one clerk doing all the posting. Accounts receivable, other than water rents, are set up in an Accounts Receivable ledger in the ordinary way.

Depreciation is calculated on the basis of the estimated life of each class of property. This information is determined by the engineering division, and a composite rate used. The composite method of handling depreciation, instead of basing it on each individual item, is considered sufficient for municipally owned utilities. The expense involved to break down the classification into separate units, it is believed, does not warrant that procedure. The average rate of depreciation is 1.50 per cent. It is necessary to correct the original life set-up on certain properties occasionally as some items do not depreciate as rapidly as anticipated.

## Repairs and Construction Accounting

The department maintains a storehouse, work-shop and storage yard as a division of operation. At this location all materials are stored and distributed on written orders, which carry account numbers for record purposes. A 20 per cent loading charge is made

for this service, to defray storehouse expense, and this loading charge is added to the cost of the various jobs. In other words, this division of the department is self-supporting. There is also a 5 per cent loading charge on capital outlay construction work for general office overhead expense. Approximately 4,500 items are carried in stock and a perpetual inventory of about 500 of the larger or more active items is kept.

All new construction or work of any description requires a numbered work order, approved by the proper officials, as authority for the superintendents or foremen to proceed with the work. The work order contains information of detailed estimated costs, plans and specifications of work to be done. A sufficient number of copies are made to supply all interested employees. All statements for material, labor, etc., pertaining to the job, carry the work order number and are sent to the accounting division for tabulation and recording.

An inventory of all department property is made by a traveling auditor, whose work is spread over the entire year. The material is placed in a loose-leaf binder and is used extensively. This employee has considerable traveling to do as the plant is scattered over an area which stretches from 10 to 150 miles from the city in various directions.

The Denver Water Department is involved in several activities that do not ordinarily come under the jurisdiction of water officials, for instance, the operation of five farms that are leased to tenants, two on a monthly rental basis and three on a crop share arrangement. An inventory of crops planted is made in the spring of the year so that an intelligent check may be had at the end of the year. The department also operates three irrigating canals for delivery of water to farmers. One of these canals has a capacity of 600 second-feet of water, is 82 miles in length, and serves over 700 customers.

A report which contains a complete detailed record of all operations is published annually. This report is a very convenient reference record.

The books of the water department are examined annually by a public accounting firm and its report of findings is made to the governing body—the Board of Water Commissioners. Public accountants' reports are important since they represent the opinion of impartial investigators. Unless proper records are kept, the work of the accountants, in preparing the report, is made difficult and therefore costly.

# Relation of Meter Rates to Distribution System Conditions and Other Factors

***By Charles H. Capen, Jr.***

MANY efforts have been made to correlate and standardize meter rates so that they will conform to some reasonably uniform pattern. Most of these efforts have proceeded along the line of the standard form of rate schedule adopted by the A.W.W.A. on May 24, 1923 supplemented by a series of reports given in the JOURNAL for September, 1923 (1). This schedule recommended a service charge and three steps: 25,000, the next 225,000 and all over 250,000 gallons per month as the basis for sliding scales. A fourth step was suggested for large cities or cities with industries using large quantities of water.

The above schedule has two fundamental defects. In the first place it works a hardship on those small stores or industries, or even large residences, which use considerably more water than ordinary dwellings, but not enough to be benefited by the second slide or scale. Secondly, it considers the problem only in the abstract without regard for the influence of elevation, type or source of water, type of community served, pumping cost and other related factors. It is the purpose of this paper to outline the net effect of some of these influences.

One of the most common and most important yardsticks used is that of population. Invariably any comprehensive table will show that the cost of water, which ultimately determines meter rates, varies as a function of the inverse ratio of the total population. Figures prepared by Metcalf and Eddy in 1925 (2), and by the writer in 1936 (3) showed average rates, in relation to population, as given in Table 1.

These two sets of figures are, of course, not entirely comparable, since one is based on meter rates only while the other is based on

A paper presented on June 26, 1941, at the Toronto Convention by Charles H. Capen, Jr., Principal Sanitary Engineer, Office of U. S. Army, Zone 2, New York City.

revenue for all water produced and, therefore, shows the effect of leakage and other waste. Assuming, however, a general loss of 20 per cent between water produced and water recorded by meters, and considering the volume sold to large consumers at low rates, the third column in the table, if adjusted for these conditions, would bear a remarkable likeness to the second column.

The writer has shown that an equation for the relation between Columns 1 and 3 may be written in the form:

$$R = \frac{365}{P^{0.2}} \qquad (1)$$

where $R$ is revenue in dollars per million gallons and $P$ is population in thousands. It is distinctly noticeable that the figures in Column

TABLE 1

*Relation of Meter Rates and Revenue to Population*

| POPULATION RANGE | AVERAGE DOMESTIC METER RATE PER 1,000 GAL.* | AVERAGE REVENUE PER 1,000 GAL. PRODUCED† |
|---|---|---|
| Over 1,000,000 | $0.13 | $0.08 |
| 250,000 to 1,000,000 | .17 | .11 |
| 100,000 to 250,000 | .19 | .13 |
| 25,000 to 100,000 | .22 | .17 |
| Below 25,000 | .31 | .22 |

* Metcalf and Eddy—based on study of 51 cities.
† Capen—based on study of 165 cities.

3 of Table 1 are about $\frac{2}{3}$ of those in Column 2. Accepting this as an approximation, a relation between meter rate and population may be written in the form:

$$MR = \frac{50}{P^{0.2}} \qquad (2)$$

where $MR$ is the meter rate in cents per 1,000 gallons and $P$ is the population in thousands.

For comparative purposes, Table 2 shows the ratio of meter rates for various populations based on Equation 2. A town of 5,000 population for instance would be expected to have a rate nearly twice as great as a city of 100,000 and four times as great as a city of 5,000,000 population.

### Elevation

Much time and thought have been given to consideration of equalization of water rates wherever more than one schedule is in use because of elevation. Equalization, as used here, does not mean a leveling of all rates, but rather a proportioning of rates to some justifiable yardstick. To accomplish this in a manner satisfactory to all consumers is by no means an easy problem. The onus of justifying any stand taken is usually placed directly on the shoulders of the water works engineer or superintendent.

TABLE 2

*Ratio of Meter Rates for Cities of Various Sizes*

| POPULATION | RATIO OF METER RATES* |
|---|---|
| 5,000,000 | 0.46 |
| 1,000,000 | .63 |
| 500,000 | .73 |
| 100,000 | 1.00 |
| 50,000 | 1.15 |
| 10,000 | 1.58 |
| 5,000 | 1.82 |

* Taking rate for city of 100,000 population as 1.00.

It is not difficult to locate instances of rates varying with elevation, but to analyze them and show their reasonableness is a task of no small proportion. If the truth were known, it seems likely that few high level rates are adequately charged for in proportion to the added cost of service. On the other hand, some supplies, both gravity and pumped, have to pass water through pressure regulating valves to some of the lower levels. Potentially this water costs even more than high level water because of initial and maintainence costs on the regulating valves. A paradox of this kind defies easy explanation.

Because of the availability of figures, the writer has selected a group of rates in northeastern New Jersey as an example. In this area there are 33 sources of supply serving 70 separate retailing agencies. The quarterly bill of each of the retailing agencies was computed for a household of five persons using 40 g.p.d. per capita. These rates were arranged in a table with respect to the elevation at which water was delivered. Solving by the method of least squares, the following equation was obtained:

$$QR = 2.75\,E - 4.12 \qquad (3)$$

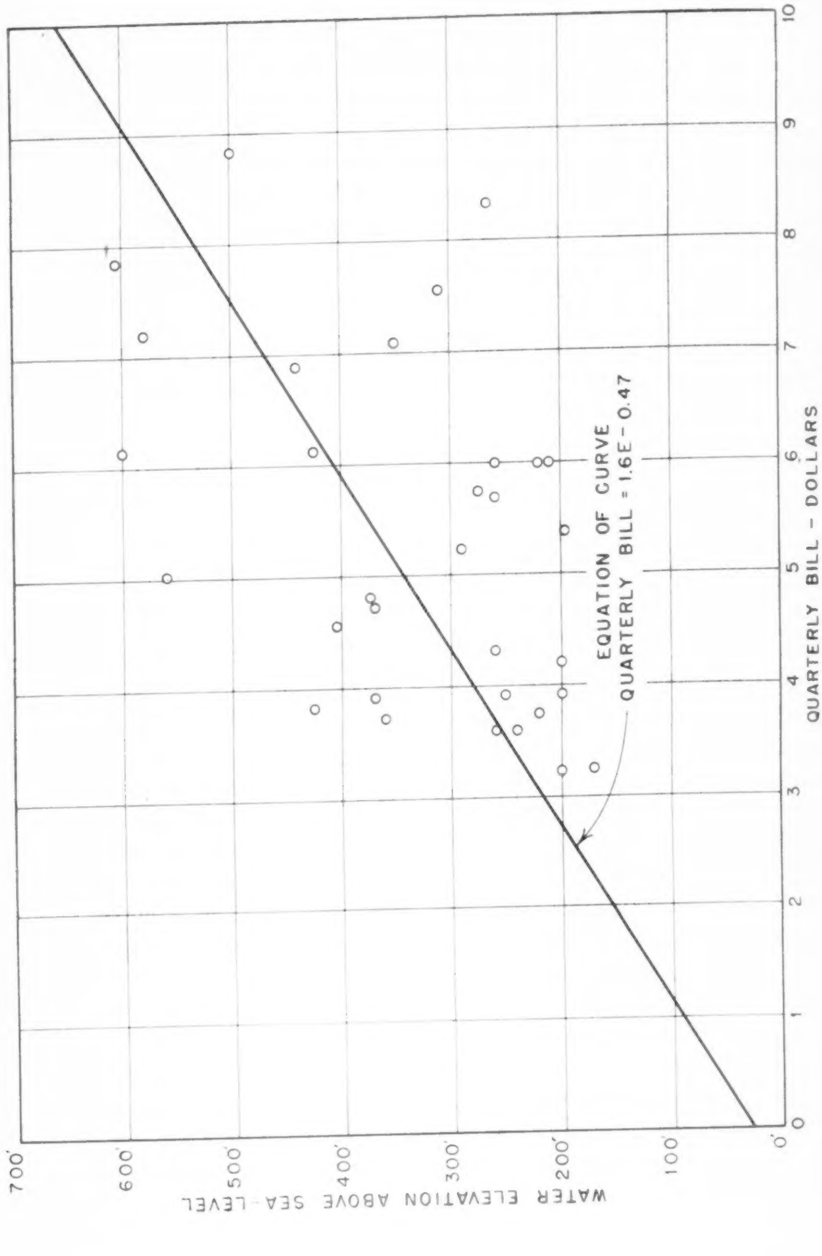


Fig. 1. Relationship Between Rates and Elevation

where $QR$ is the quarterly rate in dollars and $E$, the delivery elevation in hundreds of feet above sea level.

Omitting all supplies of less than 1 m.g.d. output, the result for 27 retail agencies becomes:

$$QR = 1.6\,E - 0.47 \quad (4)$$

The curve for this equation is shown in Fig. 1. Equations (3) and (4) are not, however, as widely separated in the average part of the elevation range as might at first be supposed. Table 3 gives an idea of the results to be obtained in solving the two equations.

In Table 3 it is demonstrated that, within the elevation range of 300 to 600 ft., the approximate increment of cost, for all practical

TABLE 3

*Relation of Quarterly Rates to Elevations in Northeastern New Jersey*

| ELEVATION ABOVE SEA LEVEL | QUARTERLY RATE FOR 74* AREAS | QUARTERLY RATE FOR 27 AREAS OF OVER 1 M.G.D. CAPAC. |
|---|---|---|
| 200 | $1.38 | $2.73 |
| 300 | 4.13 | 4.33 |
| 400 | 6.88 | 5.93 |
| 500 | 9.63 | 7.53 |
| 600 | 12.38 | 9.13 |
| 700 | 15.13 | 10.73 |

* Some retail agencies have more than one rate.

purposes, may be taken to be slightly over $2.00 per quarter per 100 ft. of elevation. Since the quantity of water used is 18,000 gal. the increment of cost per million gallons per 100 ft. is about $120.00, or $1.20 per million gallons raised per foot. Assuming distribution costs to be half of this, production cost would also be half or $0.60 per million gallons raised per foot. Pumping costs usually vary from a minimum of about $0.05 per million gallons raised per foot, for large supplies, up to $0.25 for small supplies. It follows therefore that pumping is not the major part of production cost entering into the elevation at which water is delivered.

The general situation may be more forcefully emphasized by comparing Fig. 2, showing the water level or pressure areas in northeastern New Jersey in 100-foot increments, with Fig. 3, which shows the cost of water based on quarterly bills as previously described. It is particularly noticeable that all of the low priced water is delivered at moderate or low levels while the bulk of the high levels have high priced water.

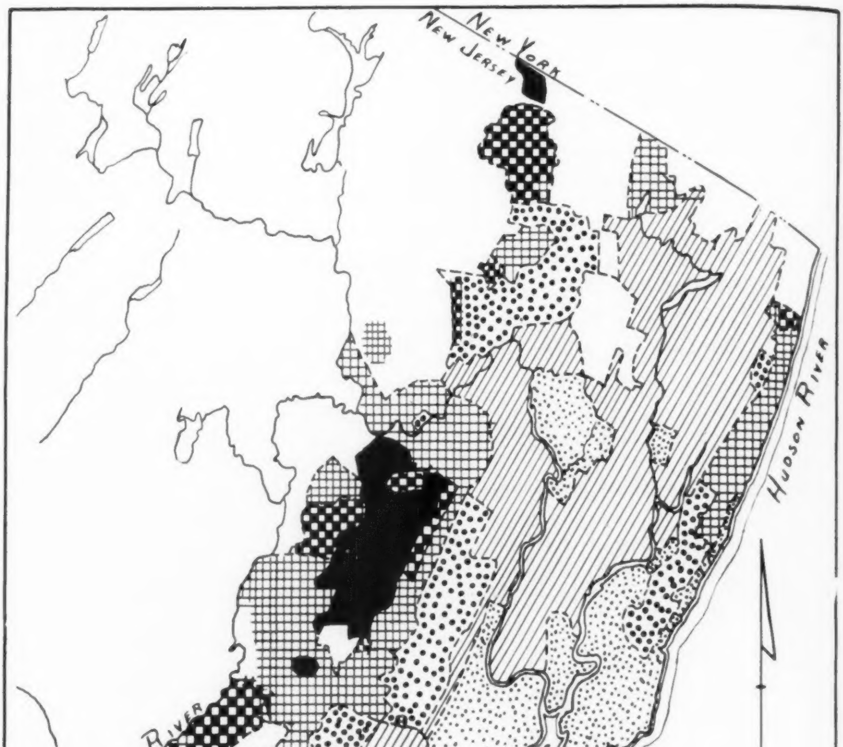


FIG. 2. Pressure Areas of Water Supply Systems of Northeastern New Jersey

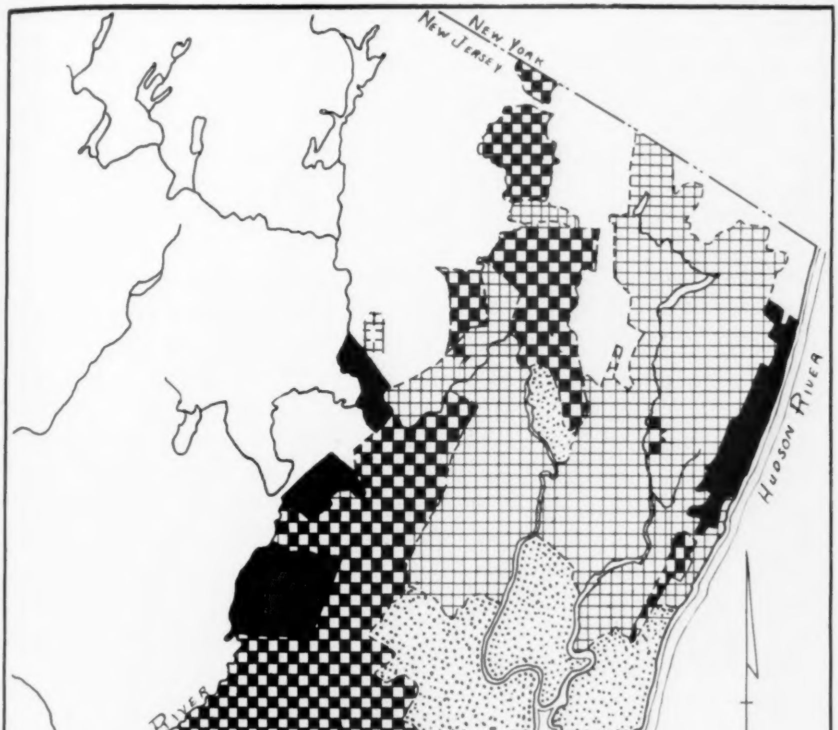


FIG. 3. Cost of Water in Northeastern New Jersey

## Proximity of Supply to Consumer

Except in cases involving long, expensive aqueducts, the location of a supply with respect to the center of distribution has less effect than would normally be supposed. One small municipality in northeastern New Jersey has wells located near its geographical center yet its rates are fairly high. On the other hand, in this same area, a large city, with its source many miles away, enjoys the lowest rate in the region.

The situation may be more clearly realized by taking the cases of cities in the United States serving more than 1,000,000 population. Of these, Boston, Los Angeles, and New York obtain supplies from a distance and their rates are relatively high. Cleveland, Chicago, Detroit and Philadelphia obtain water from nearby sources and their rates are low. Since some of these cities are metered only in small measure, a comparison of meter rates alone is not sufficient for comparison. Examination of the total revenue per million gallons, however, indicates that the large cities which have nearby supplies receive less money per unit volume than those whose water sources are at a distance.

While the rates in cities having a population range between 100,000 and 1,000,000 do not exhibit as uniform or as striking a case as the larger ones, it may definitely be stated that in a preponderance of this group too, distant sources of supply are coupled with relatively high rates while nearby sources are generally found to coincide with moderate to low rates.

## Areas Outside of City

Perhaps no other phase of water supply is fraught with so much political dynamite and jockeying as the question of how much to charge the little fellow outside the gates. A review of the practice throughout the country reveals widely divergent opinion on procedure. Perhaps one of the best digests of the proper method to evaluate such service was made by the City of Detroit a few years ago. The study revealed the possibility of somewhat inconsistent variations in rates charged to the several suburban areas, and sometimes justifiably so.

There is a general feeling in large cities that consumers outside the political boundary should pay more for their water. An exception exists in Westchester County where New York City sells water at cost delivered to that point, an agreement that was negotiated at

the time some of the rights-of-way through the County were obtained Since this omits the item of cost of the expensive tunnels under the City, the County obtains water for less cost than large consumers in the City. Usually the outsider is willing to pay a reasonable premium but he can hardly be blamed for protesting against paying double the City rate, particularly if his good neighbor just across the "right side" of the boundary line happens to remind him of it on numerous occasions.

One strange anomaly exists in the case of the two municipalities of Garfield and East Paterson in New Jersey. Originally Garfield had wells within its own limits. Wishing to tap a more promising well field, it arranged to establish a larger supply in East Paterson and to sell water at wholesale to the latter. Through its own distribution system, East Paterson now retails water to its citizens at a lower rate than obtains in Garfield. Furthermore the East Paterson department realizes a profit while the Garfield system operates at a loss.

Recently, several water agencies in New Jersey, who had been competing at destructive rates for the wholesale business of other municipalities, agreed to establish a uniform minimum price of $85 per million gallons. This has gone far to stabilize the water market and to eliminate price cutting.

Before closing comments on this phase of rate factors, attention should be drawn to the details of ownership shown in Fig. 4. The several conditions shown there constitute a vivid picture of causes for wide variations in rates.

## Discounts

There is so little uniformity in discounts that no general rule or suggestion can be made. The percentage discount and number of days in which it is allowed, both exhibit an exasperating degree of variation that defies comparison.

During the worst days of the depression it became necessary for many municipalities to institute the reverse of a discount—the surcharge. New York City led the way with a 50 per cent increase to most consumers. This has passed the stage of a surcharge and has become a new rate schedule. In large measure it is helping to finance the new Delaware River supply. Some question has been raised as to the possibility of the revenue being greater than required.

Other cases of surcharges up to 15 or 20 per cent were frequent. These additional charges were made for the purpose of meeting

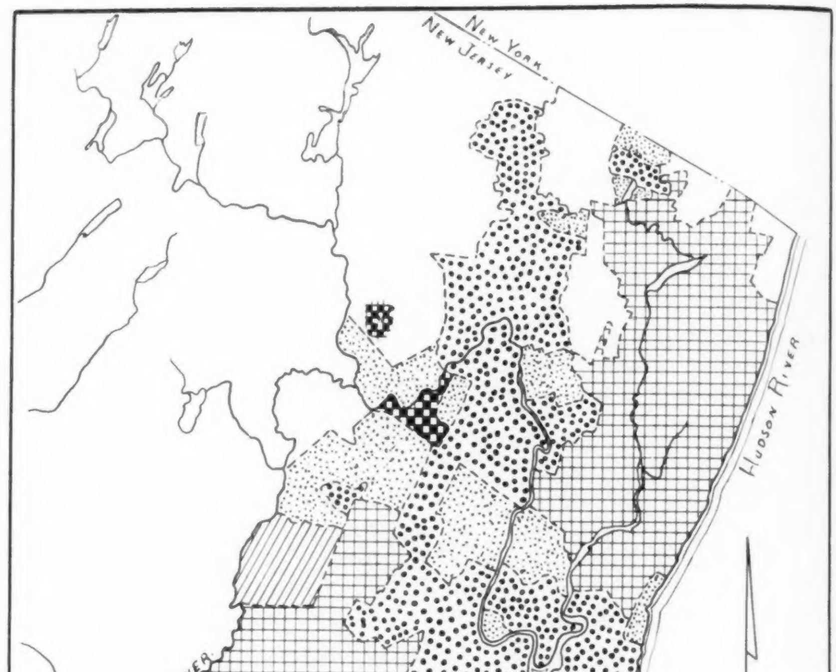


FIG. 4. Ownership of Water Supply Systems of Northeastern New Jersey

deficits caused by reduction in use of water, and, hence, revenue, during the depression, as well as to pay for expansion during the late Twenties, the debt service on which did not begin to be felt until the early Thirties.

One of the best arrangements for variations in rates is that in use in Elizabeth, N. J. This city bought its distribution system from the Elizabethtown Water Co. in 1931 and made contracts for purchase of water at wholesale from the company and from the City of Newark. With its supply costs thus firmly established, other costs were cut. Four successive rate reductions of about 5 per cent each were invoked. With a fair degree of stabilization reached, a practice, whereby discounts on bills were made on a percentage basis that did not endanger reserves but reflected earnings, was established. Discounts under this method may vary from time to time. The effect is to make each citizen who pays a water bill feel that he is a stockholder to whom will accrue the profits of a well managed department. The psychological effect is inspiring.

Many private companies were pressed to make rate reductions during the depression. Frequently they were in a position where a surcharge would have been far more welcome. To their great credit it must be said that they have managed very well through a severe financial crisis.

## Debt Service and Budgets

Few water superintendents need to be reminded of the burdensome effect of the large debts incurred during the lush Twenties. The effect of this on rates has already been mentioned under the preceding heading. In most instances the peak debt service has been passed and there is now a financial breathing spell. Surcharges in most cases cannot be relinquished because improvements omitted during the depression now demand attention and funds must be made available to meet the new debt. To put part of the debt service in a municipal budget is not good business. A municipal water department should be just as self-supporting as a private company. Conversely, the practice of milking the water department to keep down the tax rate is just as undesirable. Many meter rates reflect these practices.

In a most comprehensive and informative book on water supplies in the Chicago region, White (4) called attention to 96 metropolitan areas of 100,000 population or over in the United States. The digest of the water supply situation in some of these was outlined and it is

evident from the comments contained, and from other information available, that most, if not all, of these areas are troubled with the rate problem. In the Chicago area 168 water systems are listed. Elevations are quite uniform and nearly all supplies are either from Lake Michigan or ground water. Meter rates show variations similar to those elsewhere. One notable exception is the City of Aurora, with about 50,000 people, where the domestic rate is $0.72 per 1,000 gallons, but drops to $0.10 per 1,000 gallons for large quantities. Ratios such as this defy explanation except by those well acquainted with the situation.

Data on many metropolitan areas indicate that most of them would welcome a vigorous and well established body that could adjudicate or regulate rates and other allied problems.

## Other Factors

While this paper is intended to present a somewhat comprehensive digest of the topic, many of the remaining factors of influence will have to be considered only briefly and still others of lesser importance omitted. Following are mentioned some of the most important of the factors:

*Treatment of Water:* Complete treatment of water, including filtration, costs from $4 to $12 per million gallons and generally represents less than 10 per cent of the total cost of water delivered to the consumer.

*Density of Population:* Cost per connection decreases as density of population increases up to the point where tunneling is necessary to get under other sub-surface obstructions. In this case the cost may start to swing in the reverse direction.

*Type of Ground for Mains:* Rock excavation for pipe lines is an item that can increase capital expenditures to a great degree and may materially affect rates. Topography has an important bearing. Hilly country makes for higher rates—flat country for lower ones.

*Ownership:* Private companies must of necessity charge more because of the important item of taxes. Returns to them by the inch-foot or equivalent hydrant rental charge may, and often does, offset much of the tax cost. Necessity of paying dividends is another item in private company operation which tends to raise costs.

*Service Lines:* Much argument can be invited by discussing who should pay for the service line and meter. There is a great lack of uniformity. It is estimated that this factor affects ultimate cost to the consumer by about 5 per cent.

As a result of this study the following general conclusions as to influences or conditions under which meter rates normally vary have been reached:

1. Rates are inversely proportional to the 0.2 power of population (see Table 2).
2. Rates are directly proportional to elevation.
3. Rates vary with remoteness of supply, i.e., the nearer the supply, the lower the rate.
4. Consumers living in areas outside city limits pay up to 100 per cent more than those located in the city.
5. Discounts for prompt payment are by no means uniform.
6. Surcharges on bills, invoked during the depression, have in many cases become permanent.
7. Periodic rebates, based on earnings, are the best method of control and management.
8. Water departments should be self-sustaining and should be operated as independently as possible, with meter rates as a foundation of financial practice.
9. Metropolitan areas have in all cases aggravated rate problems. Reasonable regulation in each such area is desirable.
10. Complete filtration increases cost of operation about 10 per cent.
11. Rates vary inversely as the density of population, except in some very large cities.
12. Rates in hilly country are higher than in flat country. The presence of rock also increases rates.
13. Private companies must charge more than municipal departments, largely because of taxes.
14. Consumer-borne costs of service lines should decrease rates about 5 per cent, and vice versa.

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# Meter Settings

## *Indiana Section Committee Report*

DURING the past year, the Indiana Section organized a Technical Committee, under which various sub-committees have been detailed to investigate and report on the various problems of the water works field. The report of one of these, Sub-Committee No. 4 on Meter Settings, as prepared by T. E. Milligan, Chairman, is presented below.

This report is given in outline form, listing in detail the comparative advantages and disadvantages of outside and inside settings and noting the conclusions of the committee on the basis of its investigations.

### Outside Meter Settings

*Advantages*

1. Meters are more accessible for reading and repair.

   a. The number of repeat readings, which are costly, is reduced.

   b. The meter can be read without inconvenience to the consumer, which tends to promote good will, especially in inclement weather.

   c. There is no accumulation of water on the basement floor if the meter leaks or if it has to be repaired.

   d. Back-calls for service of the meter, as in reading, are eliminated.

2. It is a great aid in preventing waste from leaks in the service between the basement and the property line, and thus eliminates

A committee report presented on April 24, 1941, at the Indiana Section Meeting, Indianapolis, Ind., by T. E. Milligan, Chairman of the Committee and Complaint Investigator, Fort Wayne Water Works, Fort Wayne, Ind.

the constant ill feeling as to the responsibility of consumer and water department in regard to underground leaks.

3. In some cases there is less damage by freezing, as many basements are poorly constructed.

4. It reduces the ability of the consumer to tamper with meter.

*Disadvantages*

1. Cost of installation is higher.

2. The dials of meters become dirty and are difficult to read accurately. The glass on the register becomes clouded with condensation, making it impossible to read the dial without removing the glass or breaking it. When the glass is removed, damage to the register results.

3. Raising or lowering the meter box to conform with the grade of streets or lawns is costly.

4. In some localities there is greater damage from freezing, owing to soil conditions.

*Problems Involved*

1. *Proper distance from top of ground to top of meter:* In this respect two major objectives are to be considered: one, the ease of reading and removal for inspection; the other, frost protection.

The replies to a questionnaire seemed to indicate that the most satisfactory distance is 18 in. This distance prevents damage by frost, while less distance is more satisfactory for reading, but leads to damage by frost in severe winters. In Fort Wayne, Ind., most meters are 18 in. deep and no frost damage has resulted. If greater distance is used, reading becomes difficult, and in a few cases meters will become submerged in surface water and mud.

2. *Proper tile for meter boxes:* There is a great need for a continuous tile, to prevent the weakness of joint in the use of two tile, which admits frost. To the committee's knowledge, there is no material which is light enough in weight, with enough durability and inexpensive enough, to be used.

Composition tile meets all qualifications except cost. It is a good insulator which will protect risers to meters. A 4-foot tile weighs 143 lb. as against 240 lb. for vitrified tile. It comes in 13-foot lengths and can be cut to desired lengths with a cross-cut saw.

As to the use of vitrified tile or concrete, this is usually a matter of preference. Vitrified tile is slightly more expensive. The real

problem is the joints between tiles. This can be solved by using regular bell end vitrified tile or rubber joint concrete tile. The initial cost on these types is higher, but they will probably pay dividends in the long run because they are lighter in weight and probably less conductive.

The use of single- or double-covered boxes is a controversial matter. There is no doubt as to the extra frost protection offered by the double cover, since there is a dead air space between the lids; also, the seepage of mud through the top cover seals the joint at the second cover. The additional cover offers more protection to the meter register, since much of the mud and water seeping through the top lid is held by the second cover, thus making for a cleaner dial and easier reading. The interior cover also gives some protection in case a meter box lid is broken, and this, in some cases, prevents accidents. The single cover, however, is less costly to install and adds to speed in reading, since only one cover need be removed.

*Conclusions*

1. The top of meter should be 18 in. below ground level.

2. Meter tile should be of large enough diameter to protect the meter from frost and to allow enough space for ease of removal for inspection—usually 18 to 20 in. for $\frac{5}{8}$ in. x $\frac{3}{4}$ in. meters, and 30 in. for a double setting.

The tile should be either one-piece or two well jointed pieces, and should be placed 1 ft. below the maximum frost depth for the locality.

The use of meter setting devices is a matter of choice for each superintendent.

3. In setting tile for meter box, the fill around the tile should be clay or loam, well tamped, as these soils offer more protection against frost than sand or gravel.

4. Care should be taken to have the risers as near the center of the box as possible. Risers should never be closer than 3 in. to the wall of the tile.

5. The curb cock may be either inside or outside the meter pit. The best practice is to have two valves, one outside, and one inside the box near the meter.

6. The service pipe should be at least 2 in. below the meter tile to provide a cushion for the pipe and to give a perfect seal at the bottom of pit.

## Inside Meter Settings

*Advantages*

1. Cost of installation is low.

2. In most cases there is less freezing, as most houses have furnace heat.

3. The meter is easier to read, as the registers are cleaner.

4. The meters are easier to remove for repairs.

5. The meter settings are not affected by the changing of street or lawn grades.

6. The meter settings are not affected by snow and ice.

*Disadvantages*

1. Repeat trips for reading and removal and repair are often necessary.

2. The reading of the meter is an inconvenience to the consumer, especially during inclement weather.

3. The basement floor is dirtied if the meter leaks and when it is removed for repair.

4. Consumers tend to block the meter, thus making reading impossible for several months.

5. Water is lost, due to leaks between the curb cock and the basement.

6. The location of the meter invites tampering by the consumer.

*Problems Involved*

There has been much laxity as to the correct position of the meter; that is, many have been set vertically, or on an angle. It is highly recommended that meters be set in a horizontal position for more accurate registration and better service. Either the service should be such that meter can be set horizontally, or a proper setting device used.

Meters should be located as near as possible to the service entrance to the basement, to prevent the consumer from tapping the service on the unmetered side.

The difficulty which needs the most consideration at this time is the valving of the meter setting. In many cases, in modern homes, the meter is in the recreation room, and, with only one valve at the

meter, a large amount of water from the house line is usually spilled on the floor when the meter is removed for inspection. This leads to loss of time and, in some cases, to loss of good will.

*Conclusions*

1. The meter should be set in a horizontal position.
2. The meter should be set as near as possible to the service entrance to the basement, but in a free space.
3. All meters should be set with two valves, one on the outlet and one on the inlet sides.
4. Meter connections and the dial should be sealed in the best manner possible to prevent tampering. In both inside and outside settings, the meter should be set by water works men.
5. Care should always be taken to provide proper meter tail-pieces.
6. The space should be the proper distance between tail-pieces to prevent damage and inconvenience when the meter is removed for repairs.

T. E. Milligan, *Chairman*
Wm. Shoemaker
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# Cement Lining of Water Mains at Akron, Ohio

*By Wendell R. LaDue*

THE reconditioning of 20,000 ft. of 36-inch and 14,000 ft. of 48-inch steel force mains, at Akron, Ohio, by the use of a cement-mortar lining, has already been described in the JOURNAL (Jour. A.W.W.A., 32: 1784 (1940), and in other water works publications. This paper, therefore, will be limited to a discussion of some of the operation details involved in the project, which was carried out without interruption of service to the population of 245,000 and to the city's many industries.

The 36-inch main, laid in 1913–14, consisted of lock-bar pipe, fabricated in 30-foot lengths of $\frac{1}{4}$- and $\frac{5}{16}$-inch soft open-hearth steel plates. Specifications for this pipe provided for their coating by dipping in hot "coal-tar pitch varnish." This procedure, however, was employed on only about $\frac{1}{2}$ mi. of the line, because of the difficulties encountered in controlling the mixture and the temperature of the bath and pipe The remainder of the pipe, therefore, was dipped in "Pioneer Mineral Rubber."

Leaks developed in a well-defined section of the 36-inch main after it had been in service only about four years. These were attributed to electrolytic action, and, following an extensive investigation carried on by the City of Akron, in co-operation with the Traction Company, the unfavorable condition was alleviated. The contract for the construction of a portion of a paralleling 48-inch steel main had been let before the condition disclosed by the investigation was known to exist. Following the investigation, however, lock bar steel pipe coated with "Hermastic" enamel was used for the new main, with the exception of about 4,650 ft., where conditions favorable and conducive to electrolytic action were most pronounced. In this particular section cast-iron pipe was used.

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A paper presented on June 24, 1941, at the Toronto Convention by Wendell R. LaDue, Chief Engineer and Superintendent, Bureau of Water Supply, Akron, Ohio.

Although the unfavorable electrolytic conditions had been alleviated, leaks, apparently resulting from corrosion started by this cause, continued to develop in both mains, along defined areas. In the five years previous to 1940, repairs on the two mains averaged 40 per year, each repair necessitating the shutting down and draining of a portion of the main between valves, and pumping with an increased head during the repairs. By January 1, 1940, repairs on the two mains had reached a total of over 520, of which 480 had occurred on the 36-inch main, 273 concentrated in a single 4,650-foot section. The leaks, in general, were caused by holes less than $\frac{1}{4}$ in. in diameter in the bottom of a larger corroded spot on the outside surface of the pipe, the inside surface remaining in good condition. In general, effective repairs were made by driving a drift pin through the hole, tapping the hole and inserting a $\frac{5}{8}$- or $\frac{3}{4}$-inch boiler repair plug. Where this was not possible, a plate was welded over the hole, either on the inside or the outside of the pipe, as determined from the conditions encountered.

In spite of the relatively large number of repairs, however, it was felt that, since the affected areas comprised such a small portion of the total peripheral area of the mains, some form of rehabilitation would be justifiable. Welding of the corroded pits with the attendant excavation was at once rejected as impractical and too expensive, as the lines were located principally under paved highways on which there was considerable traffic. Replacement, likewise, could not be justified. The final decision was to line the pipe with cement mortar, using the process developed by the T. A. Gillespie Corp. The adoption of this method was based on the conclusion that the pipe lines were, in general, structurally sound, needing only a seal coat to prevent the escape of water when small areas became too thin to hold the pressure.

In support of this conclusion, the engineers of the Bureau of Water Supply conducted a series of tests to determine the strength of mortar lining in case the corrosion at a single point extended over a relatively large area. Tests were made on holes varying from $\frac{1}{4}$ to $1\frac{1}{4}$ in. in diameter and pressures up to 200 lb. per sq. in. Plates, $\frac{1}{4}$ in. thick, were bolted to the ends of a short piece of 8-inch flanged pipe. One plate was tapped for a water supply line and combined air vent and pressure gage connection, the other being the test plate, prepared by drilling a hole in the center of a $\frac{1}{4}$-inch plate, to which a

$\frac{1}{4}$- by $\frac{1}{4}$-inch piece of steel, bent to form a ring $7\frac{1}{8}$ in. in diameter, had been welded to form a seal ring (Fig. 1).

A 1:1 mix of mortar, prepared as nearly as possible in the manner of that to be used for lining, was applied within the ring and allowed to cure under water for a period of two weeks. At the end of this period, the plate was bolted to the pipe and, after removing the air, pressure was built up by a hand pump. Pressures were increased in increments of 20 lb., holding each for a period of several minutes

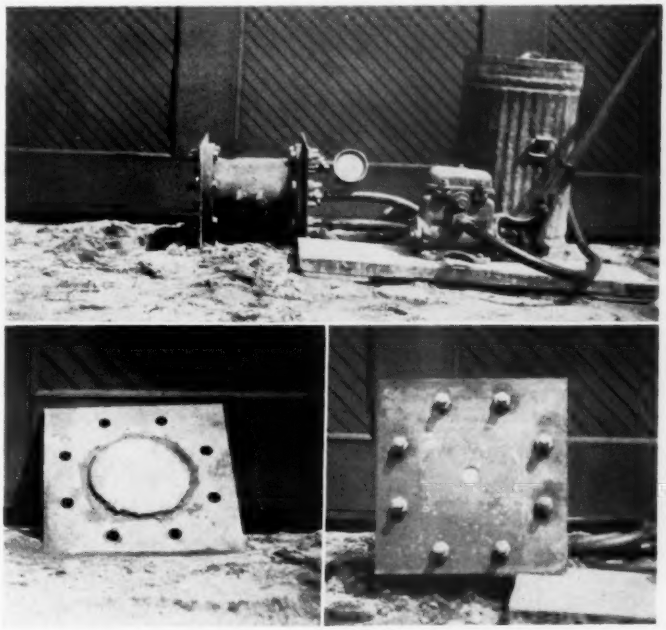


FIG. 1. Equipment Used in Testing Strength of Mortar Lining

before applying additional pressure. Weeping through the mortar started with a pressure of 40 lb. per sq. in., and increased with increased pressure, but at no time could it be described otherwise than as "weeping." After the completion of each test, the mortar lining was carefully examined and no evidence of cracks or other damage could be observed. Later test plates containing 1- and $1\frac{1}{4}$-inch holes were tested by connecting the flanged pipe directly to the city main (40 to 50 lb. pressure). The weeping through the mortar started as before, but after 72 hr. stopped completely.

It is to be noted that the mortar samples were tested at more than twice the maximum head to be expected on the force main and that the $1\frac{1}{4}$-inch hole (the largest size tested) is 2.8 times the area of the holes tapped for the $\frac{3}{4}$-inch boiler repair plugs. It was evident, therefore, that a $\frac{1}{4}$-inch mortar lining would safely span such holes as were likely to exist in the steel force mains. This observation, however, is not to be understood to suggest that sections of force main, containing holes $\frac{3}{4}$ in. or less in diameter be lined without adequate repair, but rather to emphasize the ability of mortar lining to resist failure due to small holes which may develop in the future.

## Description of Work

The process of cleaning and lining was carried on under an unusual three-way arrangement whereby:

1. The Works Progress Administration furnished labor for excavating, backfilling, hand cleaning of the pipe, plastering, and other necessary work, and furnished the sand and cement for the lining.
2. The City of Akron furnished labor, material, and equipment for all cutting and welding, for repairing the main, and for the necessary cuts for entering and removing equipment and material.
3. The T. A. Gillespie Corp., through a contract with the City of Akron, provided the equipment for the mechanical cleaning of the pipe (through the National Water Main Cleaning Co.), for placing the cement lining, and provided general supervision over the project. (Shortly after the signing of the contract, the Centriline Corp. of New York acquired the cement lining interests of the T. A. Gillespie Corp. and completed the contract by assignment.)

The project involved three distinct operations: (1) preparing the pipe for cleaning and lining; (2) cleaning; and (3) placing the lining.

## Preparing Pipe for Cleaning and Lining

As previously stated, old leaks in the main had been repaired by the insertion of boiler patch plugs from the inside of the pipe. The heads of these plugs projected into the pipe as much as $1\frac{1}{2}$ in. and had to be burned off before the cleaning machine could be sent through. Cleaning operations developed approximately 200 additional holes which had to be repaired before lining.

Practically all leaks were repaired by welding a 4- x 4- x $\frac{1}{4}$-inch plate over the hole, either inside or outside as conditions warranted. In some instances the entrance of ground water through the hole pre-

vented the making of a tight weld. Where this occurred, excavations were made alongside the main and the ground water lowered by pumping. In some instances, where even this failed to stop the outside leakage, tapered lead plugs were driven into the hole.

Inlet manholes spaced at about 1,000 ft., supplemented by holes cut into the top of the pipe, permitted the entrance of the cable from the welding machines to the torches. Two portable welding machines and four operators were kept at work burning and welding continually, to keep ahead of the lining operations. A portable generating plant furnished power for operating the lining machine, for lighting and for charging the storage battery cars.

## Cleaning the Mains

The mechanical cleaning of the mains was carried out by the National Water Main Cleaning Co. of New York. Its apparatus consisted of stiff-spring steel scrapers attached to structural steel rings in such manner that the outside diameter of the scraping edge was somewhat greater than the inside diameter of the pipe. A short funnel section was used to compress the scraping edges for inserting the machine into the pipe. The line valves on the 48- and 36-inch mains are 42 and 30 in. respectively. It was necessary, therefore, to remove the machine from the main at each valve and re-enter on the other side, since the cleaning machine could not be collapsed or otherwise made smaller.

The process of mechanical cleaning was, as follows:

A 7-foot section was cut from the pipe adjacent to one of the line valves controlling the section to be cleaned. The cleaning machine was introduced and the pipe section replaced. At the far end of the section another piece of pipe was removed to permit the discharge of the water during the cleaning process and the removal of the cleaning machine. The machine was then driven through the pipe by water pressure derived from opening the line valve in back of the machine and admitting enough water to maintain a speed of 200 ft. per min., which rate was found to give best results.

Waste water carrying the particles of coating removed from the pipe flowed past the machine and out through the open end of the pipe at the far end of the section.

To prevent injury to the pipe, due to the sudden exit of the cleaning machine, a sand bag stop was constructed in such fashion as to permit only about one-half of the machine to emerge from the open-

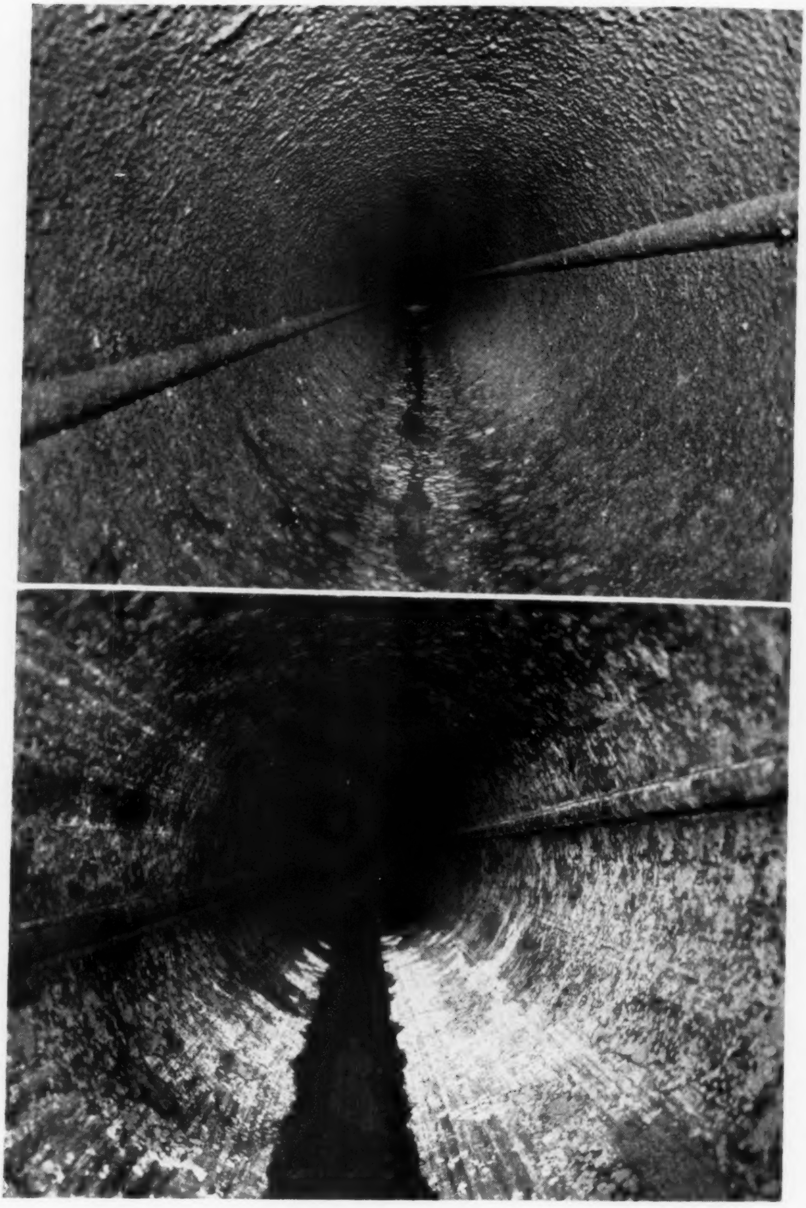


Fig. 2. 36-Inch Force Main; *Above*—Before Machine Cleaning; *Below*—After Machine Cleaning

ing. Two trips of the machine removed about 80 per cent of the coating and the small amount of tuberculation present.

At first, the entrance section was welded in place and then re-cut and rewelded for the second cleaning. This delayed the cleaning operation so greatly that a temporary coupling, consisting of a $\frac{3}{8}$-inch steel band, 6 in. in width, drawn together by two $\frac{3}{4}$-inch bolts through 3- x 3- x $\frac{1}{2}$-inch angle-iron lugs, welded to the ends of the band, was developed. Before placing the coupling, a $\frac{5}{8}$-inch circular-section rubber gasket was placed on each side of the joint. When this coupling was drawn up securely, it was found to be quite satisfactory, and when it was no longer required, the pipe sections were welded permanently.

Following the mechanical cleaning, a force of W.P.A. laborers, varying from 10 to 20 men per shift, working two shifts daily, finished cleaning the mains with hand scrapers. These workers were permitted to leave the pipe for 15 min. each 2 hr. During this interval, blowers operating through the inlet manholes and other openings, blew fresh air into the main.

The areas which required considerable hand cleaning were generally at the riveted joints and about the lock bars. All coating, scale, or other foreign matter were removed from the pipe, leaving the steel plate in a clean condition. The hand cleaning was very thorough and, considering the conditions, it was carried out very efficiently.

## Placing the Lining

The mortar lining, a 1:1 mixture of portland cement and dry-screened sand, passing a No. 16 screen, was of such consistency as to provide a dense, homogeneous lining. The water-cement ratio was carefully controlled and kept to absolute minimum. Slump tests were not necessary, since too much moisture caused the mortar to fail to adhere to the pipe. The specifications for the sand and cement were as follows:

*Sand:* Sand shall be clean, well graded, free from organic matter, and shall pass a 16-mesh screen. All sand shall receive a careful secondary screening after receipt from the pit. The sand shall be thoroughly dried out, preferably in a rotary kiln, before passing through a 16-mesh screen. Not more than 10 per cent shall pass a 100-mesh screen and not more than 2 per cent by weight shall be silt and clay.

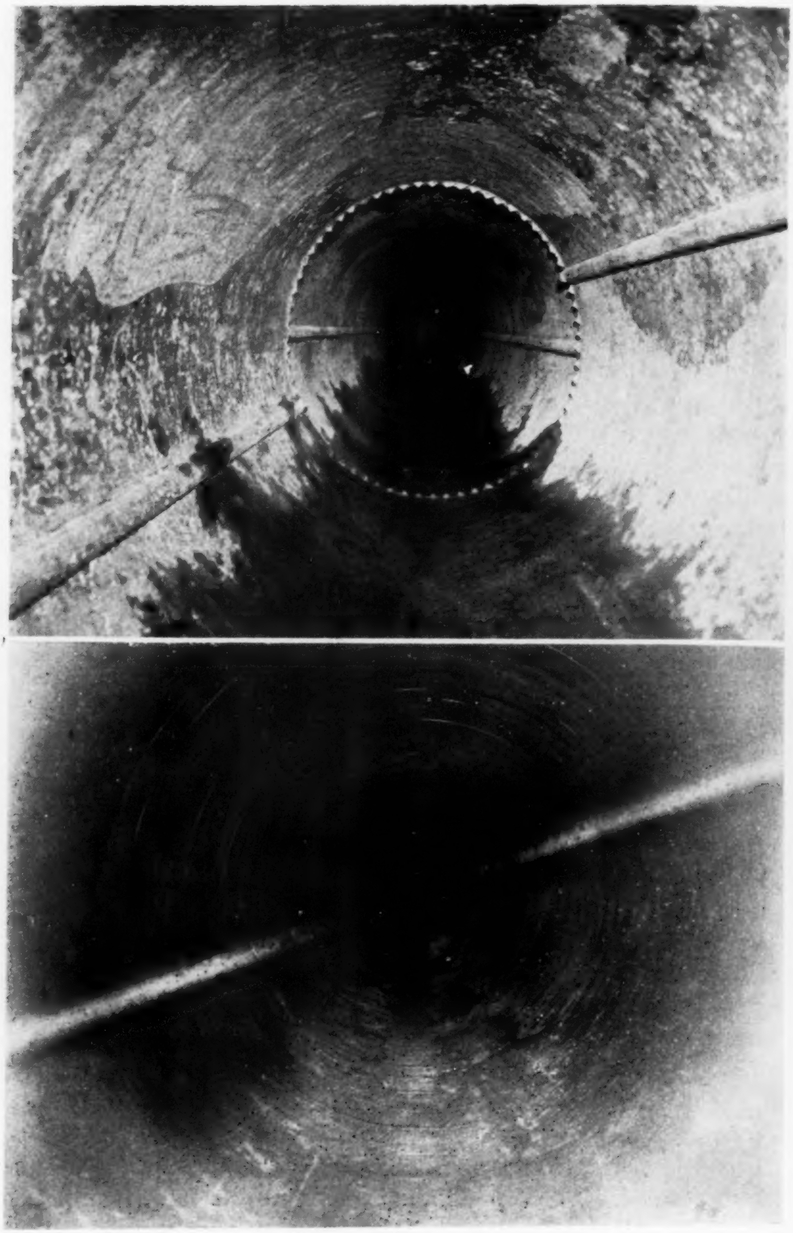


Fig. 3. 36-Inch Force Main: *Above*—After Hand Brushing; *Below*—After Lining

*Cement:* All portland cement used in the mortar for the lining shall, in general, conform to the A.S.T.M. specifications C-9-37, and shall also meet the following requirements and limitations:

The cement shall meet the sugar solubility test as required by the specifications of the Board of Water Supply of the City of New York [as listed in Requirements 1 through 8 of the Appendix to the paper by George N. Schoonmaker, p. 1690 of this JOURNAL].

If advisable, cement, shall receive a careful secondary screening after receipt from mill.

The lining, $\frac{1}{4}$- to $\frac{1}{2}$-inch thick, was placed by a rapidly revolving motor-driven head which threw the mortar against the pipe, where it was smoothed, by a series of paddles attached to the machine.

FIG. 4. Complete Lining Machine Equipment Used in Akron Project

The thickness of the lining was determined by the speed at which the machine traveled along the pipe. For $\frac{1}{4}$-inch lining, the speed was about 3 ft. per min.

At certain radial positions of the lock-bar, occasional porous sections occurred at the underside of the bar. As soon as the lining had set sufficiently to permit the cement finishers to enter the pipe, these porous sections were removed and replaced by hand plastering.

By removing the paddles, the lining apparatus could easily pass through the 42-inch and 30-inch valves, so it was unnecessary to remove the lining machine at each valve. For practical reasons, however, the travel between the outside mixer and the lining machine was limited to approximately 1,000 ft. Therefore, to supplement the

inlet manholes, openings were cut in the top of the main for introducing mortar within this limit. The lining machine traveled toward the mixing point, so there was no travel over the newly placed lining, and the lining set up quickly, so that, if necessary, the main could be placed in service within 48 hr.

The mortar was mixed above ground and conveyed to the hopper of the mixing machine in storage battery cars. Two portable mixers were used, the one not engaged in mixing being set up ahead at the next opening to prevent delay when the lining machine passed the one being used.

Upon completion of the lining, the section was sterilized with a chlorine compound and allowed to stand 24 hr. It was then flushed thoroughly before being replaced in service.

The timing and co-ordination of the work were of prime importance since inter-connecting mains had to be kept in service to supply the city with water and since the increased head on pumping equipment had to be carefully controlled. As stated before, the two parallel mains were inter-connected at intervals of 3,000 to 5,000 ft. The work was scheduled in such a manner that not more than two sections would be out of service at any one time; one in the process of preparation, the other in lining. The work was done during the spring when water demand was comparatively low, so the increase in head on the pumps was at no time troublesome.

## Occurrence of Leaks

With the advent of winter, five leaks developed in the lined section, the first being reported on December 2, 1940, and the last on February 26, 1941. Investigation, in each case, showed that the leak was caused by a crack or cracks in the welded joints of plates which had been cut from the top of the main to furnish openings for mortar and the entrance and exit of the lining machine. As the lining progressed past each opening, these plates had been replaced and the joints welded, using butt welds. Eleven such openings, varying in size from $1\frac{1}{2}$ x 2 ft. to 3 x 4 ft., were made on the 48-inch main and 25 on the 36-inch main.

It is believed that the failures in the welds were due, not only to the choice of rod, since the failures to date (measured in inches of welding) represent only about 2 per cent of the total length of the welded joints, but also to imperfect welding. Two welders were employed on this work, one furnished by the City of Akron and one

by the W.P.A. Both of these men were uncertified welders, although both had had considerable experience in general welding work.

The repairs in general were effected by welding a plate, somewhat larger in size than the original and previously rolled to the same radius as the force main, over the original plate. In one instance, where the crack extended the full width of a 36- x 48-inch plate, 4- x $\frac{1}{4}$-inch straps were welded over and completely around the joint.

Repairs thus made were of the fillet-weld type, using a No. 5 rod. A fillet weld on $\frac{1}{4}$-inch plate has a design strength of 2,500 lb. per lin.in. In addition to an unknown initial stress set up in the welded joint, as the plate cooled from the welding operation, a drop of 40°F., in temperature in the main during the winter months would set up a tensile stress of approximately 2,000 lb. per lin.in. in the welding metal.

As each repair was completed, the mortar lining in the vicinity of the welding area was inspected. In making two of the patches, the heat from the welding operations caused the mortar lining to check and loosen its hold on the steel plate. This loose mortar was removed and the lining patched before the mains were returned to service. In making the other three repairs no damage was observed to the lining other than a hair crack directly under the crack in the welded joint. Since the mortar was still adhering tightly to the steel plate, removal and replacement were deemed unnecessary.

Actual lining operations were begun on March 6, 1940, and the contract completed on June 15, 1940. During this time, as previously stated, 20,000 ft. of 36-inch and 14,000 ft. of 48-inch pipe were repaired, cleaned and lined. Since the cost to the city, including engineering supervision, was less than \$2.50 per foot of main lined, it is believed that the decision to rehabilitate the existing mains was fully justified.

The work was under the direct supervision of the author as Superintendent and Engineer of the Bureau of Water Supply, assisted by A. E. Goodman, Associate Engineer, the City of Akron's representative on the work; L. W. Bausher, Junior Engineer and O. R. Elting, Office Engineer. C. S. Erskine was the Contractor's Superintendent; and the W.P.A. Field Supervisor was A. Anderson. The Bureau of Water Supply is a division of the Department of Public Service of which W. F. Peters is Director.

# Cement Lining of Water Mains at Toledo, Ohio

*By George N. Schoonmaker*

WITHIN the past four years the City of Toledo, Ohio, has lined a total of 26,700 lin.ft. of large diameter water mains with centrifugally applied cement lining. The mains so treated have been newly laid steel pipe comprising a part of the city's distribution system. Cement lining was applied following completion of installation, backfilling, and field testing and prior to placing the mains in service. Experience to date has been confined to one 48-inch and one 60-inch main. Following is a description of this work as it pertains to the installation of cement lining on the two trunk mains.

The 48-inch steel trunk main, installed in the summer of 1937, consists of 15,302 lin.ft. of 48-inch and 128 lin.ft. of 54-inch steel pipe. The pipe itself was fabricated in 40-foot lengths, electrically welded, the wall thickness being $\frac{9}{16}$ in. It was laid in open trench with a nominal cover of approximately 6 ft. The pipe has plain ends, the joints being made with standard type Dresser couplings. The average separation of pipe ends, appearing on the inside of the pipe before lining, was 0.75 in.

Following installation and completion of backfill, this line was filled with water and tested at a pressure of 125 lb. per sq.in. Testing was done on each completed section of about 4,500 lin.ft. between line valves. Following testing and acceptance, the line was drained and work started on cleaning the interior in preparation for lining.

Cleaning the interior of the newly laid pipe presented some difficulty, principally due to accumulation of mud which found its way into the pipe during the laying operations. It was revealed that more care in preventing the entrance of mud during installation would repay itself many times in cleaning the pipe later, since it became

A paper presented on June 24, 1941, at the Toronto Convention by George N. Schoonmaker, City Manager, Toledo, Ohio.

necessary to remove a large portion of this material by hand through the inspection manholes.

To present a suitable surface for application of the cement mortar, it was necessary to wire-brush the inside surface to remove all loose accumulation of rust and, of course, clay particles which were not removed in the rough cleaning. Rags were then used to wipe the interior surface dry of all free moisture.

Following cleaning, the space between the pipe ends on the interior of the line was hand filled with cement mortar and smoothed with a trowel to present a continuous even surface across the joint. At first when these joints were not pre-filled, a depressed ring was left in the lining around the inner pipe circumference at the joint. Patching or filling this depression following lining proved unsatisfactory, so the method of pre-filling the space was adopted and gave entirely satisfactory results.

While the interior joints were being filled, all branches and openings 10 in. and smaller were filled with rags or were closed in some other way to present a continuous surface for passage over the opening of the revolving trowels of the lining machine. Following lining application the temporary closures were removed and the openings finished by hand placed lining and troweling.

At the larger openings, such as 20-inch inspection manholes and the larger diameter branches, which it was impractical to close, the revolving trowels on the machine were stopped and the cement lining applied without troweling for a distance spanning the particular opening. Later these untroweled portions of the pipe wall and branch opening were troweled by hand.

Inspection manholes are located at approximately 1,200-foot intervals throughout the length of the main. These inspection manholes, having a clear opening 20 in. in diameter, were not large enough to accommodate the admission of the centrifugal lining machine. To admit the machine, the contractor was permitted to cut two 36- by 36-inch square openings in the top of the pipe, each approximately 4,000 ft. from the end of the line. Later, following removal of the machine, these openings were closed by field welding the cut section back into place. The area was then finished by hand application and hand troweling of the cement lining.

The lining machine (Figs. 1 and 2) used in the process may be described briefly as a small compact electrically operated unit having a revolving drum approximately 12 in. in diameter attached to a hori-

zontal shaft by means of which the prepared mortar is thrown centrifugally against the inside surface of the pipe. The machine is mounted on rubber-tired wheels and is adjustable to permit the horizontal centering of the revolving head or drum in the pipe. Attached to other horizontal shafts, and operating directly following the throwing head, are two sets of extension arms (which revolve in opposite directions) to which are attached steel trowels which smooth the freshly applied mortar. The cement mortar reaches the revolving drum through a hollow shaft from a receiving hopper at the control end of the machine. Power is supplied to the machine by means of a cable connected to a portable power plant. The rate of travel of the machine longitudinally in the line fixes the thickness of mortar applied to the

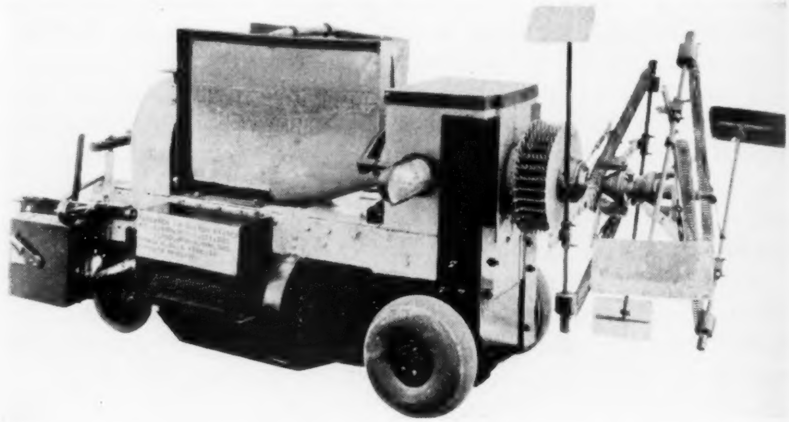


FIG. 1. View of the Lining Machine

pipe. An operator sitting on the forward end of the machine adjusts and controls its entire operation.

Because of the length of the lining machine, it was necessary to dismantle it partially to permit its introduction into the main through the openings. After re-assembly, the machine was moved to one end of the pipe line and put into operation.

The mortar was mixed above ground and introduced into the pipe through the 20-inch inspection manholes where it was dumped into the hopper of the conveying truck. This truck, rubber tired and self-propelled by storage battery power, transported the mortar to the lining machine.

When the machine first reached the 36- by 36-inch opening in

the pipe it was removed, reversed in direction, moved to a predetermined point in the opposite direction from the opening and lining operations resumed.

Specifications required that the cement lining be from $\frac{3}{16}$ to $\frac{1}{4}$ in. in thickness. Particular care was exercised by the operator to avoid placing too thin a lining. Actual test measurement following place-

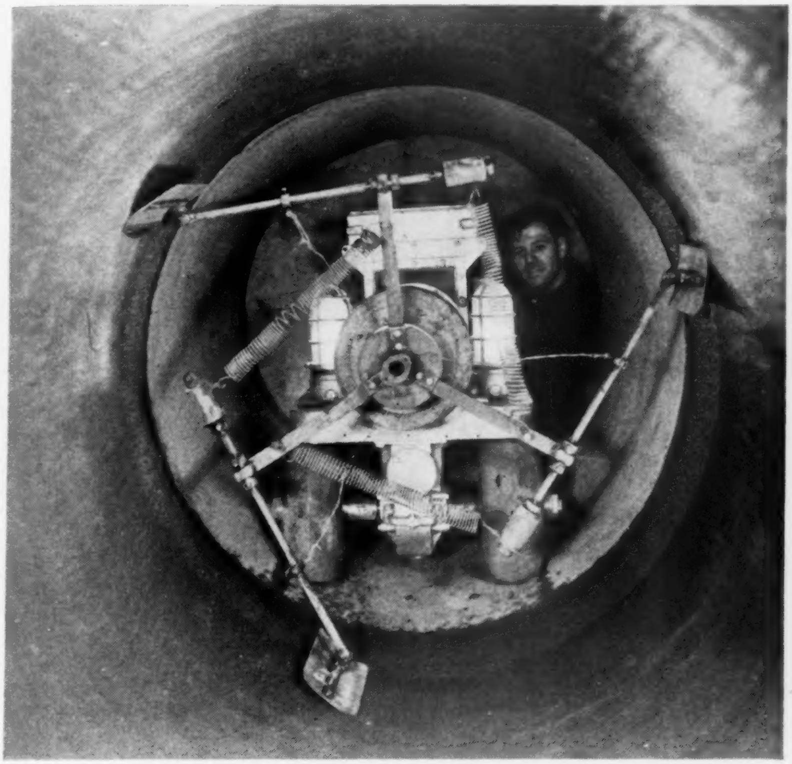


FIG. 2. Lining Machine in Operating Position in Main

ment and curing indicated an average thickness of $\frac{1}{4}$ in., prevailing evenly around the entire circumference. The centrifugally applied lining was extremely dense and the continuous mechanical troweling produced an even continuous smooth surface (Fig. 3) throughout the entire length of pipe line wherein the machine operated. It is generally impossible to determine the exact location of pipe joints after lining, when the aforementioned method of prefilling the joints is used.

At certain places, such as bends and reducer sections, it was impossible to operate satisfactorily the trowels on the machine. At these places, the cement was thrown centrifugally onto the pipe with the machine trowels disconnected; and later the sections were smoothed by hand troweling or, in view of the short distances involved, left untroweled.

The initial curing of the freshly applied cement mortar is an important operation in the installation of this type of lining. Imme-

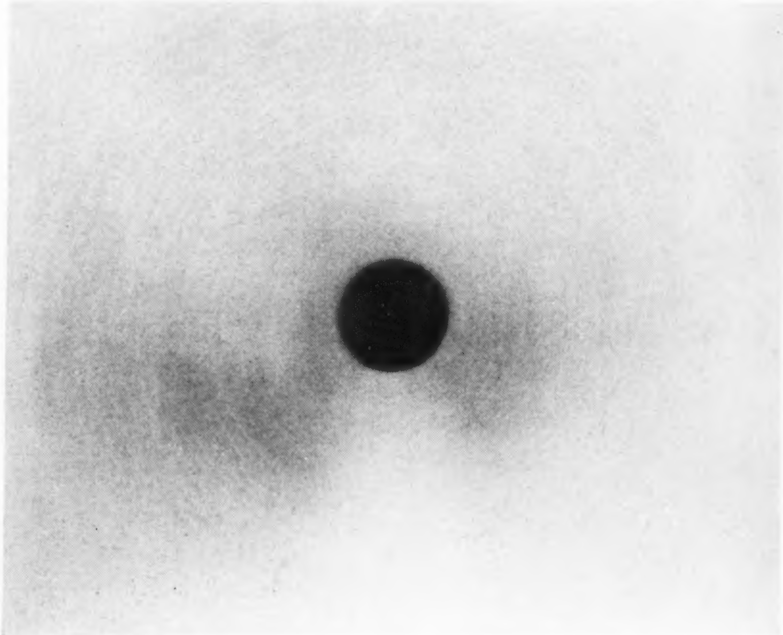


FIG. 3. Smooth Surface of Pipe Interior

diately following a day's run, the manholes within that run were closed, and portable bulkheads erected at each end of the run to prevent the circulation of air and consequent escape of moisture. Twelve hours after application, it was possible to step on the lining without injuring it. As soon as practicable after that time, moisture was introduced into the section and continued until the mortar had set satisfactorily. The minimum moistening period allowed was 72 hr.

The specifications for the 48-inch line required that either steam or

atomized water be introduced into the newly lined sections for curing purposes. Steam was first tried on this line, but results were unsatisfactory in that the steam would completely condense within a few feet of the end of the steam hose, thereby leaving the remainder of the section without benefit of moisture. This method was abandoned in favor of hand spraying the cement surface and the latter procedure was specified exclusively in later contracts.

In the setting of the cement mortar, some cracking, of course, occurred. The cracks, mostly of the "crazing" or "hair-crack" variety, were nearly all circumferential although continuous circumferential cracks very rarely occurred.

When the line was reopened for inspection following eight months' use, practically all these cracks had disappeared and the few remaining visible ones (mostly at the joints) were closed tight. Furthermore, the lining itself, as determined by tapping with a light hammer, proved to be adhering tightly to the pipe metal, even at the center of the arch, where, if any place, it might be expected to become loose.

On the occasion of failure of the steam curing trial mentioned above, a 60-foot section of lining was later found to have dried too quickly, with the result that this section cracked unduly and had to be removed and replaced. This was the only instance of unsatisfactory work requiring replacement in the entire combined length (26,700 ft.) of 48- and 60-inch pipe lined.

### Inspection and Flow Tests

Immediately following completion of lining and final inspection, the 48-inch main was filled with water and kept filled for approximately eight months. At the end of this time, the entire line was drained and opened for inspection. As previously mentioned the lining itself was found to be tight and sound throughout, with absolutely no evidence of deterioration. Actually, to all appearances, it was in better condition than when first placed.

As a check on the flow characteristics claimed for this type of lining, the City of Toledo employed the Pitometer Company to make independent measurements to determine the value of the Williams-Hazen coefficient, *C*, for the line. This observation was made one and one-half years after completion of the lining on a relatively straight section of the line, totaling 9,035 ft. between gage points. The results of two sets of readings taken during the test indicated values of 140 and 142, or an average of 141.

## Lining of 60-Inch Main

The 60-inch crosstown main installed during the year 1940, consists of 11,270 lin. ft. of 60-inch steel pipe, fabricated and laid in 60-foot lengths, electrically welded, with a wall thickness of $\frac{9}{16}$ in. It was laid in open trench in city streets with a cover of approximately 7 ft. Like the 48-inch line, it has Dresser coupling field joints. Both the 48- and 60-inch lines, including the couplings, are coated on the outside with bituminous enamel. The 60-inch line constitutes a section of the new high service crosstown trunk main for Toledo's Lake Erie Water Project now nearing completion.

The pipe cleaning and lining operations for the 60-inch main followed, in all essential details, the operations described for the 48-inch line. Actual placement of the lining, however, proceeded somewhat more uniformly and expeditiously, probably due, in part to the greater experience gained by the lining machine contractor during the intervening two years, and in part to the experience gained by the field engineers on the 48-inch job.

Lining of the 60-inch pipe line was completed on December 28, 1940, and the line was filled with water early in January, 1941. It has not since been drained and opened for inspection, nor has it been tested for its Williams-Hazen *C* value. When this line was installed, provisions were made for the later use of pitometer measuring devices, and it is intended to make flow tests in the near future when the line is in full operation as a part of the new Lake Erie Water Supply Project.

No difficulties were encountered in the installation of the cement lining in the 60-inch trunk main. The average lining thickness is $\frac{1}{4}$ in. Hand application of a fine spray of water proved entirely satisfactory for moisture control during the curing period. It is intended to make an inspection of this line prior to placing it in active service this summer and again to check the soundness of the lining and to determine if the quantity of precipitate or laitence warrants its cleansing and removal.

The equipment used in this work, including lining machine, mixers, transportation buggies, etc., are all specially designed for interior lining of large diameter mains. Some of the apparatus, particularly the lining machine, is operated under strict patent licenses and, so far as is known by the writer, only one concern in this country is qualified to use this process of cement lining application. The

lining contractor carries with him a portable engine-generator power plant, his own electric motor operated mixers, and practically all other tools and equipment necessary for the work. Necessarily, the workmen are skilled in the several operations, particularly the equipment operators. These men are brought in by the contractor. Common labor and a few cement finishers for the hand work are obtained locally.

The cement lining for the 48-inch trunk main was installed by the T. A. Gillespie Co. of New York City, under direct contract with the City of Toledo. The job cost a total of $43,050.26, or a unit cost of $2.79 per lin.ft. for the 15,430 ft. of pipe lined. The work was completed in a total of 44 work days. The average daily run was 350 lin.ft. and the maximum run for an 8-hour day was 1,350 lin.ft.

Cement lining of the 60-inch trunk main was done by the Centriline Corp. of New York City, successor to the T. A. Gillespie Co., using the same process of application. This job was done by subcontract under the general contractor who installed the 60-inch main. The unit bid price for the lining was $2.50 per lin.ft., making the total cost $28,174.40. The work was completed in a total of 16 working days. The average daily run was 705 lin.ft. and the maximum run for an 8-hour day was 1,680 lin.ft.

In the design of 75,000 ft. of large diameter steel pipe lines for the Toledo Lake Erie Water Project, the specifications were written so as to permit either bituminous or centrifugally applied cement lining. P.W.A. regulations, under which this project is being constructed, require open competition on all material specifications and contract award to the lowest bidder. These regulations normally would have eliminated all possibility of securing cement lining due to its higher initial cost (average $2.50 per ft. as against $0.75 for bituminous).

To place the two types of lining on a competitive basis, pipe to be cement-lined was specified $\frac{1}{16}$ in. less in plate thickness. With this advantage, cement lining bids were lower than those for bituminous linings on the 11,270 ft. of 60-inch pipe. On all other steel lines where this differential prevailed, however, bituminous lining proved to be cheaper competitively and, therefore, was installed.

The position of the city in offering this advantage to the cement lining company on these new pipe lines was considered justified economically because of the anticipated permanency of cement as against bituminous lining, as a protection against corrosion and tuberculation,

and, therefore, as a means of preserving the high flow efficiency of the new pipe line indefinitely.

At the present time, the City of Toledo in installing 7,000 lin.ft. of 42-inch steel trunk main as an extension of the previously described 60-inch line. This is not a P.W.A. project and cement mortar lining has been specified exclusively for the job.

For enlightenment on specification details, the latest specifications for cement lining as applied to the recently completed 60-inch diameter trunk main are given in the Appendix, below.

## Appendix—Specifications for Lining With Cement Mortar by the Centrifugal Method*

*Description*

If cement mortar is to be employed as a lining for the steel main, the main will be completely installed, tested, and, at least, partially backfilled previous to placing the cement mortar lining as herein specified.

Cement mortar lining shall be placed throughout the entire length of main, by the method and in the manner herein defined, the intent of this specification being to secure a complete protective lining, dense, smooth, adhesive and durable, which will improve the hydraulic properties of the line and maintain, as nearly as possible, its original capacity.

*Work Included*

The contractor shall thoroughly clean the main, well in advance of starting the lining.

He shall provide all necessary equipment, labor and materials to line completely the main pipe line and appurtenances as herein specified.

* EDITOR'S NOTE: *These specifications are not to be confused with the A.W.W.A. Standard Specifications for "Cement-Mortar Protective Coating for Steel Water Pipe of Sizes 30 inches and Over." The A.W.W.A. Specifications advanced from a tentative to standard basis as of June 26, 1941.*

*The Specifications quoted by the author and appearing as an appendix to his paper relate to the Toledo contract.*

*Mortar*

Mortar shall be composed of portland cement and sand mixed in proportion of one part cement to from one to one and one half parts of sand by volume, the amount of sand to be determined by the characteristics of the product available.

Sand shall be clean, well-graded and free from organic matter and shall, if ordered, be washed. It should be dried and screened through a twelve- (12) mesh screen.

Portland cement shall conform, in general, to the standard specifications for portland cement of the American Society for Testing Materials (Serial Designation: C9-38) and, in addition shall meet the following requirements:

1. The insoluble residue shall not exceed 0.50 per cent.
2. The loss on ignition of freshly ground cement shall not exceed 1.50 per cent.
3. The percentage of alumina ($Al_2O_3$) shall not exceed 6.00.
4. The percentage of magnesia ($MgO$) shall not exceed 4.00.
5. The percentage of silica ($SiO_2$) shall not be less than 21.50.
6. The percentage of sulfur trioxide ($SO_3$) shall not exceed 1.75.
7. The ratio of the percentage of alumina and ferric oxide, $Al_2O_3/Fe_2O_3$, shall not be less than 1.20 nor more than 1.80.
8. The cement shall be so thoroughly calcined in a rotary kiln that:
   a. The tensile strength of standard mortar Ottawa sand briquettes will be not less than 290 lb. at 7 days and not less than 400 lb. at 28 days.
   b. Thin neat cement slabs 2 in. x 4 in. in size, after 28 days submersion in a 10 per cent solution of sodium sulfate, the solution being neutralized daily, will show no signs of disintegration, cracking, crazing or checking. Slight softening of the sharp edges shall not be considered ground for rejection provided that the specimen when broken across the corners shows a dry interior and is strong and brittle.

Cement and sand shall be mixed in an approved machine, with water, carefully controlled at a minimum ratio with the cement, for a sufficient period, approximately five (5) minutes, to obtain maximum plasticity and shall be immediately used in the work. Mortar which has attained its initial set shall be discarded.

*Placing*

The lining shall be placed by machine, the essential features of which shall be: (1) a head, revolving at high speed projecting the mortar against the wall of the pipe at a high velocity (the impelling force shall be centrifugal and no air shall be utilized in the process of mixing, conveying or application); (2) attachments troweling a smooth surface finish to the applied mortar; and (3) progression of the machine ahead of the lining so that nothing shall come in contact with the troweled surface until it has attained its initial set. Only such machines as have successfully placed cement linings similar to that herein specified and which have been in service and proved satisfactory for at least one year, will be acceptable. Control of the mechanical placing of the mortar shall be provided to assure a uniform thickness of lining, this thickness to be a minimum of $\frac{3}{16}$ inch and a maximum of $\frac{1}{4}$ inch, on the plate surface. Special attention shall be given, where necessary, to insure smoothness.

Openings in the pipe line, leading to air-valves, blow-offs, manholes or other appurtenances, shall be acceptably plugged or covered, during the placing of lining, to prevent the admission of mortar, and such temporary protection shall be removed promptly after the lining has obtained sufficient set. All openings shall then be lined, in accordance with directions of the engineers, in a manner fully to protect the metal from corrosion.

*Curing*

Immediately upon the completion of the lining of each section of pipe between manholes, or of a day's run of the machine, the section of the pipe shall be closed at each end and the manhole openings covered. Starting early on the following day, the lining shall be sprinkled throughout with atomized water. Bulkheads shall be maintained in place to prevent circulation of air and sprinkling shall be repeated as often as required to keep the lining moist for a period of seventy-two (72) hours from the time of its completion.

Every precaution shall be taken to prevent injury to the completed lining and, in the event that examination at any time within one (1) year after placing, discloses damaged or unsatisfactory work, sections may be ordered, and shall be, cut out and replaced in an acceptable manner at the expense of the contractor.

# Cement Lining of a Water Main at Cincinnati

*By Carl A. Eberling*

ONE of the projects of the Cincinnati Water Works Department during the past year was the cement lining of 5,123 ft. of 48-inch cast-iron main. This main, installed in 1907 as part of the "New Water Works" placed in service during that year, was one of the two supply lines into the elevated portion of the eastern section of the city, where, due to the topography, pressures range from 70 to 190 lb. per sq.in. Actual working time on this project was from November 26 to December 5, 1940.

In laying the main, the engineers who designed and supervised construction of the New Water Works adopted their own standards for cast-iron pipe and fittings, and these were the reverse of present day specifications, Class A pipe being extra heavy. Because of this departure from general practice, the 48-inch main that was lined actually measured $48\frac{1}{2}$ in. in diameter and 2 in. in thickness; and since such an out-sized pipe requires the exercise of extreme care in cutting out of sections (because they must be replaced as the work proceeds), special pneumatic cutting tools were designed for the job by the Department staff. Using this equipment, it required about 8 hr. to make a complete cut.

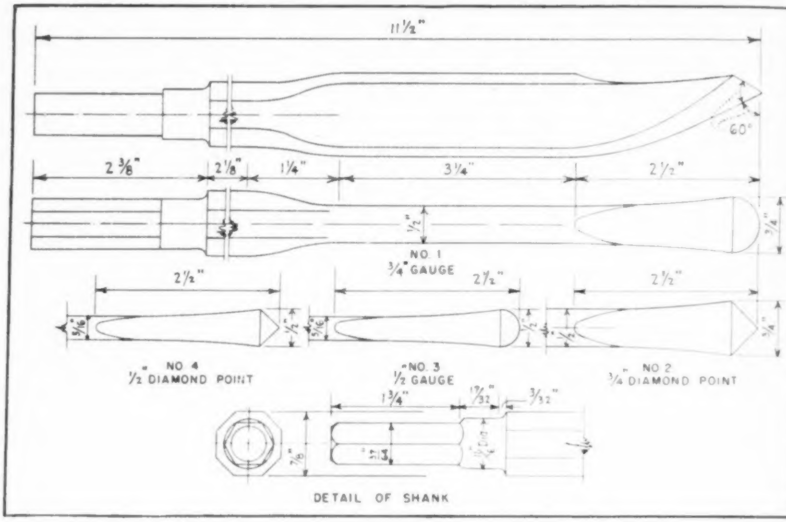
In cleaning the pipe, six sections were removed. One at one end of the main and another, within 1,000 ft. of the other end, were 7 ft. long; and the four intervening sections were each $2\frac{1}{2}$ ft. long. After use, all these cuts were replaced with mechanical couplings.

The location of one large opening 1,000 ft. from the end of the main was necessitated by the fact that that portion of the main was laid under a newly constructed concrete highway, the opening of which was not permitted. It was necessary, then, to clean this 1,000 ft.

A paper presented on June 24, 1941, at the Toronto Convention by Carl A. Eberling, Superintendent, Water Works Department, Cincinnati, Ohio.

of main by hand, using scrapers, while the remaining 4,123 ft. was cleaned mechanically, with equipment and under supervision furnished by the National Water Main Cleaning Co.

Before lining, the main was traversed and all open joints were plastered with cement mortar, flush with the inside face of the pipe. The lining was then placed, $\frac{1}{4}$ in. thick, with equipment, personnel and materials furnished, under contract, by the Centriline Corp.




Special Cutting Tools Designed by Cincinnati Department

The value of the Williams-Hazen coefficient, $C$, as determined previous to cleaning the main, was 93. After cleaning, no determination was made because of the necessity of placing the main back in service; but at a later date, when the main was again in service after lining, it was found that the value of $C$ had been raised to 143.

# The Development of Cement Lining of Water Mains

*By H. Seaver Jones*

THE topic "Cement Lining of Pipes" has basked in the limelight at several meetings of the Association in recent years. Possibly this is due to the gradually dawning realization that we are observing a rebirth of a practice rather than the creation of an innovation, for there is really nothing new about the use of cement as a protective lining for pipes.

In 1836, 105 years ago, the French Academy of Science of Paris, France, went on record as follows: "Hydraulic cement is, of all the compositions combining facility of application with cheapness, that which adheres best to castings, is most indestructible, and prevents most effectually all oxidation (corrosion) and consequent formation of tubercules."

This country did not have to wait very long for a demonstration of this method of pipe protection, for 96 years ago the first cement-lined sheet-iron pipe of which we have actual record was laid in Jersey City, N. J. It was in reference to this line that Leonard Wood of the Board of Water Supply of New York City reported:

"The better linings have increased the sustained carrying capacity for tuberculating waters by 20 to 100 per cent. Of these better linings no other can yet show as long and successful a service record as cement. In one or another kind of water pipe, cement linings have been in constant use since the first cement-lined sheet-iron pipe was laid in Jersey City in 1845."

This type of pipe construction was very generally followed for many years, particularly along the Atlantic Seaboard. Short lengths of what might be characterized as stove-pipe were rolled up, crudely riveted and a batch of hand-mixed natural cement mortar, apparently compounded with scant regard for screening and grading,

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A paper presented on August 7, 1941, at the Western Pennsylvania Section Meeting, Erie, Pa., by H. Seaver Jones, President, Centriline Corporation, New York City.

was dragged through the interior of the pipe and pressed against the walls by means of a spreader. Various devices, frequently of the sleeve or coupling type, or threaded joints on the smaller sizes, were used to connect the pipes, and the exteriors were surrounded with cement, or not, depending upon conditions in the ditch or upon the whim of the water works man in charge. Although these mains served their purpose adequately for many years, the majority faded out of the picture as water pressures increased far beyond originally anticipated demands, or as conditions required larger sized pipe. Cast iron, usually tar coated, gradually superseded these cement mains.

## Long Service of Cement Linings

One characteristic was always identified with the old cement-lined pipes. No corrosion seemed to attack the interior metal, underlying the cement mortar, and, as tubercules were actually non-existent, original carrying capacities were well sustained. This fortunate attribute was finally recognized as due to the alkalinity and lack of oxygen in the film of non-circulating moisture which penetrated to the underlying plate surfaces. Operating conditions in many places permitted from 40 to 70 years of effective service. Among these, certain New England cities—Danvers, Lynn, Plymouth, Peabody—might well be cited. A 30-inch main of this type is still in operation, 72 years after installation, running from Mystic Reservoir to Somerville, Mass. Careful examination a year or so ago, when a connection was being made, revealed that the hydraulic capacity had been maintained substantially at its initial value and scarcely any evidence of physical deterioration was observed anywhere. The use of cement-lined service pipes, too, is still very general throughout New England—the continuance of a practice established more than 60 years ago.

In the light of this service, an effort has been made to recapture the protective virtues of cement by perfecting a method of applying thin cement mortar to the interior of old mains, *in situ*. Previous to the time of this development, cement linings had occasionally been used on new siphon installations or large diameter pipes by means of grouting around progressively movable forms or by the utilization of a cement gun. These processes were somewhat handicapped in certain particulars, such as cost, the necessary use of reinforcing mesh, rebound, undulations, and a resulting lining of unnecessary thickness, which made excessive encroachments on the effective diameter of the pipe. The new creative efforts, however,

resulted in the development of two processes for the application of cement in underground pipe lines: (1) the Tate Process for pipes of from 3 to 20 in. in diameter and (2) the centrifugal, or Centriline process applicable to diameters of 30 in. and greater. These new methods had the advantages of utilizing the superior present-day cement and the accumulated experiences and data regarding mixtures, grading, proper screening, water ratio, etc., many important features obviously unknown in the earlier work.

While the Tate method discovered the answer in the smaller field by using a perfected form of spreader, the centrifugal method permits the application of cement exactly as mixed above ground, without rebound or spatter, in a thin, dense lining cast upon the interior pipe walls by means of a rapidly revolving dispensing head. The finished lining is smooth, without undulations and the compact electrically driven equipment, the constant progressive speed of which depends upon the thickness of lining being applied, permits rapid prosecution of the work. On one reconditioning job, 21,000 ft. of 48-inch pipe were centrifugally cement lined in 25 working days, employing a single shift. This speed element is particularly important in reconditioning work where a pipe line can be spared from service for only a limited period.

Though these newer methods were conceived with no other thought in mind beyond the restoration of carrying capacity and the physical rehabilitation of old mains, several contracts have been awarded for the centrifugal lining of new pipe installations. Engineers appear to be giving increasing thought to the advantages gained, as well as to the disadvantages avoided, when the interior protection is applied after the main has been laid, backfilled and tested. This eliminates the troubles sometimes encountered with shop-applied coatings, which must subsequently endure the rigors of transportation, weather, storage, laying and final touching-up after installation. A cement lining applied from one end of the main to the other after everything else has been done, avoids most of these sources of trouble and minimizes the menace from workmen's and inspector's boots. Although work of this character cannot be done underground as inexpensively as in a shop, there is unquestionably a trend toward the idea that an important capital investment for pipe deserves the best possible protection in its most vital spot—the interior—for the value of a pipe line depends upon its hydraulic capacity.

In the reconditioning of old mains two things are accomplished, restoration of carrying capacity and the prolongation of life of the

pipe itself. That these are attainments of far more than temporary value is practically guaranteed by the past performance of cement linings under similar conditions. Questions have been raised at times as to how the placing of a cement lining on the interior of a steel main can be justified if the difficulties are external ones due to electrolysis or soil corrosion. This problem has been carefully weighed on more than one occasion.

### Tests Made at Akron

In Akron, Ohio, troubles had been experienced for some years from electrolytic action on the exterior of the city's eleven miles of parallel 36- and 48-inch steel force mains. Even though it was believed that the unfavorable electrolytic conditions had been alleviated, leaks, apparently resulting from corrosion started by this cause, continued to develop in both mains. A careful investigation revealed that these leaks were caused by holes less than $\frac{1}{4}$ in. in diameter, originating on the outside surface of the pipe. Resorting to tests which would simulate these actual conditions and using a comparable cement-mortar lining of $\frac{1}{4}$-inch thickness, the Akron engineers established to their satisfaction that holes not only of $\frac{1}{4}$ in. in size, but up to and including $1\frac{1}{4}$ in., could be spanned safely by this unsupported cement lining, even under water pressures of 200 lb. per sq.in. Though some "weeping" was observable after passing 40 lb. pressure in the tests, the weeping completely stopped after 72 hr. under test conditions. As this resourceful research had satisfactorily established its strength and adequacy, a reconditioning contract utilizing centrifugally-applied cement lining was awarded shortly thereafter.

A somewhat similar, but even more severe, test was subsequently undertaken in Detroit. In this test, a length of 48-inch diameter steel pipe was perforated with numerous holes, varying in diameter from 1 to $6\frac{1}{4}$ in. Each hole was then fitted with a screw plug or blank, so that an unbroken interior would be available for lining. A cement lining of the customary 1 to 1 mixture was then applied by a centrifugal machine, the thickness of the lining being graduated from $\frac{1}{4}$ in. at one end of the pipe to 1 in. at the other. After an adequate curing period, heads were inserted in the ends of the pipe, the plugs were removed from the holes, and hydraulic pressure was applied at 50 lb. per sq.in. This pressure was gradually increased until, finally, the large hole, $6\frac{1}{4}$ in. in diameter, blew out at a pressure of *305 lb. per sq.in.* The thickness of the lining at this particular hole was $\frac{5}{8}$ in. Though certain holes under this pressure showed a small

amount of weeping and others slight, almost hair-line, cracks, no other phenomena of importance were observed.

The results of these tests are far-reaching in significance and important in implication. It is generally conceded that the interiors of old mains can be effectively treated for additional lengthy periods of service. Skepticism regarding the possibility of failure of steel pipe from external corrosion or electrolysis, when so reconditioned, is greatly minimized, if not entirely eliminated, when these results are applied to actual conditions of the majority of the old steel mains and it becomes obvious that neither the ordinary working pressures nor the character of physical deterioration are insurmountable factors.

When a steel main starts to deteriorate, whether from electrolysis or corrosion, it usually does so by localized pitting not by a general breaking down throughout its entire length. These pit holes, as a rule, are pencil-size in diameter and seldom increase appreciably in size. Even great numbers of them would scarcely decrease the inherent strength of a steel plate. It is not difficult then to follow the reasoning of the Akron engineers and to join with them in the conclusion that their cement mortar lining would be capable of resisting failure due to any such holes that might develop in the future.

"Spend for Defense" is a worthy and popular slogan these days and one to which we can all subscribe. It is well to remember, however, that "all-out" defense efforts are predicated upon the well-being of our citizenry and that this in turn will require, over a period we know not how long, emphasis, and not restrictions, upon the essentials—not the least of which is water. Priorities may increasingly militate against the availability of a municipality's metal requirements but sand and cement probably will continue to be readily procurable in most localities. Reconditioning a 48-inch cast-iron main in Cincinnati increased the coefficient from 93 to 143 (Williams-Hazen formula) or 53 per cent. The coefficient on an old riveted supply main in Newark, N. J., advanced from 70 to 124 thus yielding 77 per cent increased delivery. Such substantial increases are possible when dense, smooth, centrifugally applied cement linings are utilized.

A pipe reconditioning program such as this, insuring additional water and increased life of water mains, may well be a wise precautionary defense measure as well as a far-sighted business undertaking for many municipalities at this time.

# Cleaning and Cement Lining Water Mains in Place

*By Bruce Harkness*

LOSSES in carrying capacity in cast-iron pipes due to tubercular incrustation are indeed very serious, particularly in those systems along the Atlantic and Gulf Seaboards, where reductions of 50 per cent or more have been experienced. In the past efforts have been made to alleviate the condition by water treatment and by water main cleaning, but until recently, no permanent solution of the problem had been discovered.

A number of cases where the mains have been exhumed, taken to the yard, cleaned, cement lined, and returned to service have come to the attention of the author. The City of Rosario, Argentina's second largest city, resorted to this procedure in an effort to combat the ravages of corrosion. Although the method was costly, it was far less expensive than continual cleaning and/or the discarding of old pipe lines and laying of new cement- or bitumen-lined mains. In this case the pipelines were on an average of 40 years old, and had been laid with a life expectancy of 80 years; thus, if they had been discarded altogether, 50 per cent of the original capital investment would have been lost

Water main cleaning, by what is commonly known as the "go-devil" method, has often been resorted to in the effort to maintain carrying capacities, but, due to the physical conditions brought about by this method, the pipes soon have to be cleaned again.

The author was fortunate enough to be stationed for some seven months at the Bengal Iron Company's works, in Kulti, India. During this time he witnessed the final stages of a series of extensive experiments which had been carried out over a period of some ten years in the field laboratories there. These experiments were carried

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A paper presented on August 7, 1941, at the Western Pennsylvania Section Meeting, Erie, Pa., by Bruce Harkness, Engineering Representative, Tate Pipe Linings, Inc., Andover, Mass.

out from the time the pipe left the foundry, at the time of their being dipped in bitumen at 350° F. Under observation, the new pipe coating or dip was found to contain a number of small holes, which, though not visible to the naked eye, could readily be seen through a glass as small crater-like perforations which formed minute passageways or capillaries to the wall of the pipe. Under the accelerated conditions of highly aggressive waters, it was found that these small holes soon became covered by tubercules.

## Observations on Results of Main Cleaning

After a period, the pipelines were cleaned by the usual go-devil method. On inspection immediately after cleaning, it was found that, where the scrapers or knives rode on the pipe wall, sections of the protective coating had been removed, exposing the bare iron to the action of the water, with the result that the growth of tubercules became much more rapid. These experiments and observations were carried out with the object of ascertaining how often a pipe would have to be cleaned under existing conditions in order to maintain high coefficients, and also with the object of developing suitable new pipe coatings. It was found that the intervals between cleanings became shorter, and a stage was reached when little or none of the original coating was left on the pipe.

Many water works men have had experience in pipe cleaning and its attendant discomforts, such as red water, etc. One of the numerous cases to come to the attention of the author was that of the Roaring Creek Water Co. of Shanokin, Pa., where cleaning had been resorted to over a period of years in an effort to maintain capacities. Repeated cleanings were found necessary and red water trouble was a constant burden.

The 10-inch pipe lines in this case had been laid in 1891 and were cleaned in 1930 and 1936. It was again found necessary to clean the lines in 1939, when the carrying capacity had fallen to what it was prior to the first cleaning in 1930. At the time of its last cleaning, the $C$ value had dropped to 58. In other words, cleaning proved to be but a temporary relief.

While treatment of water at the plant has met with some degree of success in isolated cases, there has as yet been designed no definite procedure which, when applied to the supply at the plant or source, will definitely prevent corrosion in reticulation systems; the effect, if any, has been to retard the action rather than to prevent it. Pipe

coatings, both of coal-tar enamel and cement mortar, which will successfully resist the action of corrosive waters, have for some time now been applied to new pipe in the foundries; but the problem of successfully cleaning and applying protective coatings to existing pipe lines in place had, until recent years, still remained unsolved.

## Methods of Placing Linings

Two methods of applying coatings of cementitious character to existing conduits in place, have been developed during the last decade: (1) the Centriline method, which is applicable to sizes of 30 in. or greater in diameter; (2) the Tate Process, for cleaning and cement lining pipelines from 3 to 20 in. in diameter

In the Tate process the pipe line to be treated is generally cut up into sections of about 350 to 400 ft. Excavations are first made at intervals of 1,600 ft. An auxiliary supply line is then laid along the top of the ground, and house services connected to this, so that a minimum of inconvenience to the consumers will be caused. Following these preparatory stages, 5-foot sections are cut from the bypassed line at intervals of 350 to 400 ft. Each section is cleaned *and* lined before proceeding to the next section.

Winches are placed at each end of the section being treated, and after the cable has been threaded through the line, a set of scrapers is drawn through. These scrapers are designed to pulverize the tubercules, as in that state they are more readily removed from the pipe. Next, a series of steel brushes in tandem with three sets of rubber plungers is drawn through the main. The brushes remove what little corrosion may have been left by the scrapers and also clean all the interstices in the pipe wall. The rubber plungers, which are a little larger in diameter than the pipe itself, by a squeegee action, successfully remove all the corrosion from the pipe, leaving it perfectly clean, dry, and ready for cement lining.

The cement mortar which consists of carefully graded and washed sand, and portland cement, is loaded into the main through a 12-foot loading pipe, which is coupled at right angles to the line by means of a Dresser coupling. When the mortar ceases to gravitate under its own weight, the power winch at the far end of the section being treated pulls a plunger into the loading pipe, thus forcing the mortar into the conduit. The plunger is again drawn out of the loading pipe by the power winch at the loading end, and these operations are repeated

until the quantity of mortar necessary to line the pipe has been fed into the main.

The loading pipe is then disconnected and the lining machine attached to the cable in the main and drawn through. This lining machine is simply a tapered mandrel which has in and around its center a series of small holes. The holes allow a certain amount of water to be squeezed from the mortar thus changing its consistency as it is compressed and placed on the pipe wall in the form of a finished lining, leaving it in a semi-dry state.

Usually two sections of pipeline are finished in a day. These sections are returned to service the next morning and the bypass along the sections cleaned and lined is moved up to the far end of the temporary service lines.

## Results on Various Projects

In Shamokin, Pa., where work has been done during the past two years, results have been very gratifying. The Williams-Hazen *C* value on the 10-inch pipe, three years after its last cleaning, had dropped to 58; but flow tests after cleaning and cement lining revealed that the value had risen to 141 on the nominal diameter.

In Wilkinsburg, Pa., work just completed for the Pennsylvania Water Co. gave very good results. Before treatment flow tests indicated a *C* value of 64. After completion of the work the value was 140 on the nominal diameter. These high coefficients are no doubt due to the fact that the lining when completed is one of continuity, all joints having been filled with cement mortar. This prevents corrosion at pipe joints and definitely stops leaks at these points.

Recently, in Danvers, Mass., work was completed on an 8-inch feeder main on which leaks had been bad and complaints, regarding the unpalatability of the water and the high iron at the tap, frequent. In some cases analyses showed that there was 240 per cent as much iron at the consumer's tap as in the water at the pumping station. The Massachusetts State Board of Health's analyses showed a serious increase in bacteria in the water, which no doubt was due to contamination at pipe joints. After cleaning and cement lining, all leaks disappeared and complaints of red water and unpalatability ceased. Further tests by the Board of Health showed that all traces of bacterial contamination had cleared up.

These cases are only a few of those where work has been done in this country during the past $2\frac{1}{2}$ years. In summing up, it may be said that the Tate Process will extend the longevity of existing mains and mean a saving, in many cases, of 50 per cent or more of the original capital investment in pipelines, will reduce pumping and maintenance costs to a minimum, will create a leakproof main, and will dispense with the necessity of repeated cleaning with its attendant bugbear, red water, for but a portion of new pipe cost.

Referring to pipelines affected with tuberculate incrustation in this country, J. E. Gibson, Manager and Engineer of the Water Department of Charleston, S. C., said (Jour. A. W. W. A., **32:** 819 (1940)):

"It is estimated that at least . . . 200,000 mi. [of pipelines in continental United States] are from 4 to 12 in. in diameter, so it can be readily seen that with the known active or aggressive waters throughout the country there is a large field and necessity for the restoration of carrying capacity of mains now laid and in service. The reconditioning of these water mains in position means that their functional life will be increased from a few years to probably as many as fifty, depending upon their present age, and that a great economic saving to the water companies and municipalities throughout the United States will be effected."

# Viability and Destruction of the Cysts of *Endameba histolytica*

*By S. L. Chang and Gordon M. Fair*

AMEBIC dysentery may be transmitted through water by the cysts of the protozoön *Endameba histolytica.* The cysts are discharged in the feces of the carrier host, survive in water for a significantly long time, pass unharmed through the human stomach, and develop into the vegetative form in the intestine. This is called excystation. Each cyst is reported to produce eight vegetative amebae (trophozoites), which multiply by simple fission and invade the tissues of the intestinal wall. The vegetative cells that are discharged in the feces die quickly and, even if ingested, are probably destroyed in the stomach. Encystment occurs naturally only in the intestine of the host during the chronic or carrier state of the disease. Photomicrographs of trophozoites and cysts are shown in Figs. 1 and 2.

Although commonly thought of as a tropical disease, from 5 to 10 per cent of the general population of the United States are believed to be carriers of amebic cysts. Infected individuals are reported to discharge cysts in numbers varying from several hundred thousand to some tens of millions per day. In polluted waters, therefore, the ratio of the concentration of amebic cysts to the concentration of coliform bacteria may be calculated to lie in the vicinity of one to one hundred thousand. This low concentration factor, together with the death of cysts in water and their removal or destruction by water treatment processes, may account for the apparent failure of the existing army of carriers to cause outbreaks of water-borne amebic dysentery on a community-wide basis.

What makes amebic dysentery an important hazard in water supplies and, therefore, deserving of continued study by sanitary

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A paper presented on June 24, 1941, at the Toronto Convention by S. L. Chang, Research Fellow, School of Engineering, and Gordon M. Fair, Professor of Sanitary Engineering, of Harvard University, Cambridge, Mass.

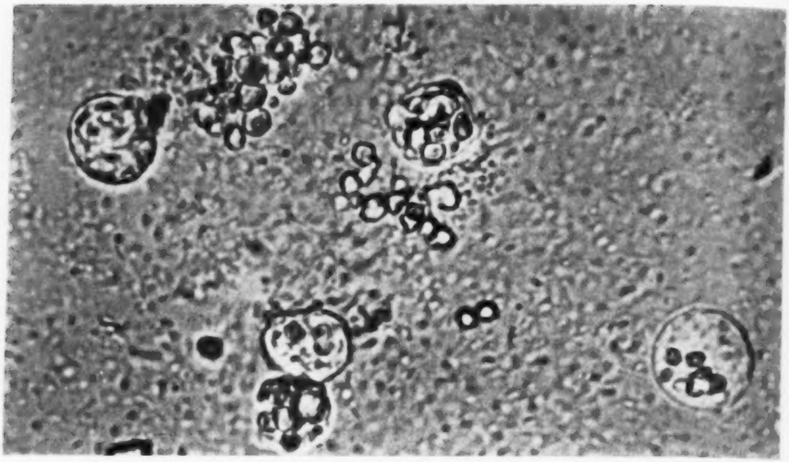

FIG. 1. Trophozoites or Vegetative Cells of *E. histolytica* from a 4-Day Culture; tube was inoculated with cysts treated with 1.0 p.p.m. of chlorine for 60 min. at temperature of 10°C. and pH of 6.1; starch granules appear free and in the cells

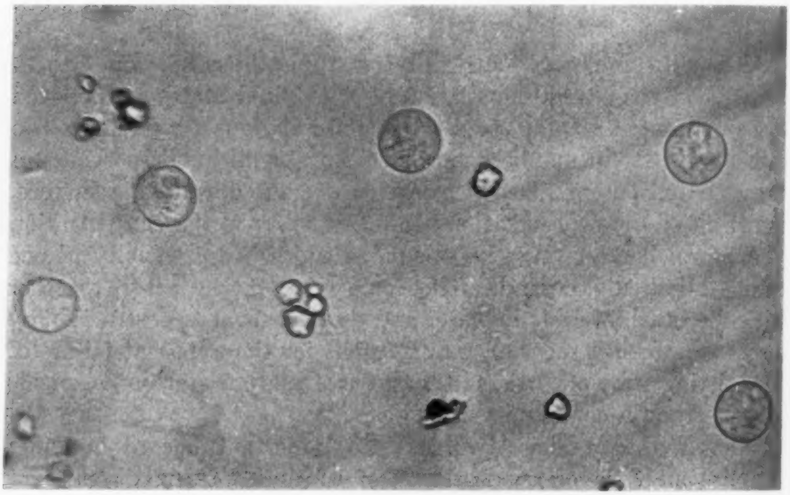

FIG. 2. Cysts of *E. histolytica*; washed from a sand filter used in the preparation of a clean suspension of cysts for experimentation

engineers, is the chance of its spread by: (1) sporadic, localized dissemination of cysts through back-flow in plumbing systems and through cross-connections in distribution works; (2) invasion of the sources of water supply in the absence of adequate general sanitation; (3) increased carrier rates associated with unhygienic practices and surroundings; (4) the use of heavily polluted water under conditions of military exigency; and (5) the sewage pollution of water distribution systems that may accompany the destructive burning and bombing of communities.

It is the purpose of this paper to present and analyze the results so far obtained in an experimental study of: (1) the length of survival of the cysts of *E. histolytica* in water at different temperatures; and (2) the reaction of the cysts to chlorination under varying conditions of water temperature, hydrogen-ion concentration, and cyst density. To a considerable extent this study was prompted by the chaotic state of the information available in the literature; and it is hoped that identification and evaluation of many of the variables involved will make possible a rational interpretation of the behavior of the cysts of *E. histolytica* in drinking-water supplies.

## General Experimental Procedure

Most of the cysts used in the experiments that are to be reported were cultivated from a pathogenic human strain of *E. histolytica*. A few suspensions of cysts, however, were prepared from a monkey strain. Since these strains showed no significant differences in behavior, they need not be dealt with separately for the purpose of this discussion. Preparation of suspensions relatively free from organic matter and adventitious intestinal protozoa other than *E. histolytica* involved: (1) cultivation of the organism in Cleveland's liver-infusion agar medium; (2) transplantation to Boeck-Drbohlav's medium without starch, in preparation for the encystment of the trophozoites; (3) transfer to an encystment medium which was developed by the junior author (S. L. Chang) and which includes a buffered phosphate-salt solution, a liver extract fluid, and rice starch; (4) destruction of the remaining trophozoites by storage of the diluted sediment from the encystment medium; and (5) separation of the cysts from the starch, by filtration before suspending them in normal saline, Ringer's solution, or distilled water. A washed culture of colon bacilli was added for the purpose of observing the behavior

of these organisms along with that of the cysts. The resulting suspension contained from 100,000 to 250,000 cysts of *E. histolytica* per ml. and from 20,000 to 200,000 *Escherichia coli*.

To determine the survival of cysts, liver-infusion agar medium was employed as the culture medium. This medium was inoculated with a heterogeneous bacterial flora in order to induce excystation and multiplication of the amebae. Staining of cysts with eosin was found to be a grossly unreliable criterion of their death and was, therefore, not employed as a measure of cyst survival.

### Viability of *E. histolytica* in Water

Suspensions of cysts in sterile distilled water, normal saline, or Ringer's solution, to the number of 26, were held at temperatures of 4, 5, 8, 21.5, 27.5, 37, and 39.2°C. until three successive cultures were found to be negative. Similarly, suspensions of cysts in natural surface waters (Charles River and Alewife Brook) and in municipal sewage of full strength or diluted, to the number of 16 with 2 controls suspended in normal saline and distilled water, were held at temperatures of 6.8 and 21.5°C. until three successive cultures were found to be negative. The suspensions contained at the inception 100,000 to 250,000 cysts per ml. and, since it was found by test that an inoculum of about 0.5 ml. containing a probable number of cysts as low as 5 would certainly produce a positive culture, survival of cysts was recorded until more than 99.99 per cent of them had died.

Examination of the results obtained showed: (1) that temperature exerted a profound effect upon the viability of the cysts and (2) that the length of survival in the various suspending fluids was not significantly different.

The observed relation between life span and temperature is illustrated in Fig. 3. The curve of best fit passing through the 44 observed points has the equation:

$$t = \frac{t_0}{\theta^T} = \frac{87.5}{1.119^T} \quad (1)$$

where $t$ and $t_0$ are the days of survival at a temperature of $T$°C. and 0°C. respectively and $\theta$ is the temperature coefficient. This curve is in accordance with the known viability-temperature relationship of primitive organisms. The length of survival of cysts of *E. histolytica*, therefore, appears to be close to three months (87.5 days) at the freezing temperatures of water, and a simple calculation will

show that this life span is cut successively in thirds by every successive rise in temperature of 10°C. (18°F.). More exactly, the temperature characteristic, $Q_{10}$, has a magnitude of 3.07. Survival at 10°C. (50°F.) is about one month (28.5 days), at 20°C. (68°F.) about 10 days, at 30°C. (86°F.) about 3 days, and at 40°C. (104°F.) about one day.

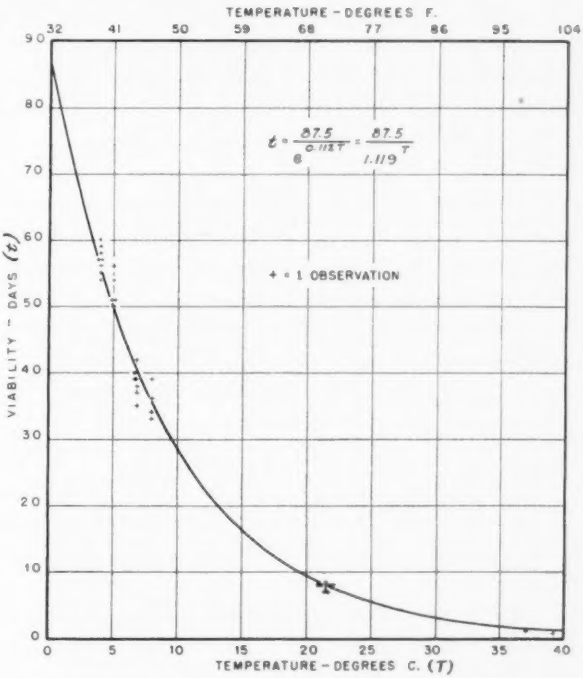


FIG. 3. Observed Viability of Cysts of *E. histolytica*; at temperatures varying from 4°C. to 39.2°C. in distilled water, normal saline, Ringer's solution, natural surface waters, and sewage

Lack of evidence that the length of survival was reduced by suspension of the cysts in natural surface waters and in sewage may imply that the cysts of *E. histolytica* have no natural enemies in water and that their death is due primarily to starvation. Sedimentation, however, may play a part in the removal of cysts from natural bodies of waters. Hydrogen-ion concentration did not appear to exert a significant effect upon the viability of the cysts between pH 6.5 and 7.1.

## Destruction of *E. histolytica* by Chlorine

The experiments so far performed were confined to the destruction of the cysts of *E. histolytica* by solutions of gaseous chlorine in water. The suspensions of cysts employed were never stored for more than two weeks. The ammonia content of the suspensions varied from 2 to 4 p.p.m. and, since the suspensions were commonly diluted from 500 to 2,000 times, there was no chance for the formation of significant amounts of chloramines. Sodium thiosulfate was employed as a de-chlorinator after it had been proved to be harmless to the cysts in the concentrations required. The pH of test samples was adjusted by adding a saturated solution of lime water or a buffering solution of hydrochloric acid and sodium acetate. Chlorine concentrations below 2 p.p.m. were determined by ortho-tolidine and those above 2 p.p.m. by starch iodide. Glacial acetic acid was added in the starch-iodide test when the pH was above 6.0. The pH was determined potentiometrically using a glass electrode. After chlorination and de-chlorination, cyst suspensions were concentrated centrifugally before planting in liver-infusion agar medium for growth observation. Separate inoculations with and without added bacterial flora were prepared. The survival of the colon bacillus was ascertained by conventional cultural procedures. In all experiments the cysts survived higher concentrations of chlorine than did the bacteria. Control tests, inoculation of negative samples of the culture medium, and other scientific safeguards were included in the normal routine.

Almost 1,000 cultures of *E. histolytica* were prepared and observed in the course of the work here reported. The cysticidal efficiency of chlorine is discussed below.

## Effects of Temperature and Contact Time

Time and temperature relations in the chlorination of water containing the cysts of *E. histolytica* are illustrated in Fig. 4. The plotted observations are confined to a density of 60 to 100 cysts per ml., or a content of total organic nitrogen of 0.095 to 0.13 p.p.m., and to a residual pH of about 7.0. The curves passed through the observed points have the equation:

$$D = \frac{D_0}{\tau^\theta}, \quad \text{or} \quad R = \frac{R_0}{\tau^\theta} \qquad (2)$$

where $D$ and $D_0$ are the cysticidal chlorine dosages in parts per million at a temperature of $T$°C. and 0°C., respectively, $R$ and $R_0$ are the corresponding cysticidal chlorine residuals in parts per million, and $\theta$ is the temperature coefficient. These curves are in accordance with the known disinfection-temperature relationships of primitive organisms. Furthermore, the curves for contact periods of 30, 60 and 120 min. are interrelated as follows:

$$D^n t = \text{constant, or } R^n t = \text{constant} \qquad (3)$$

where $t$ is the time of contact in minutes and $n$ is a measure of the

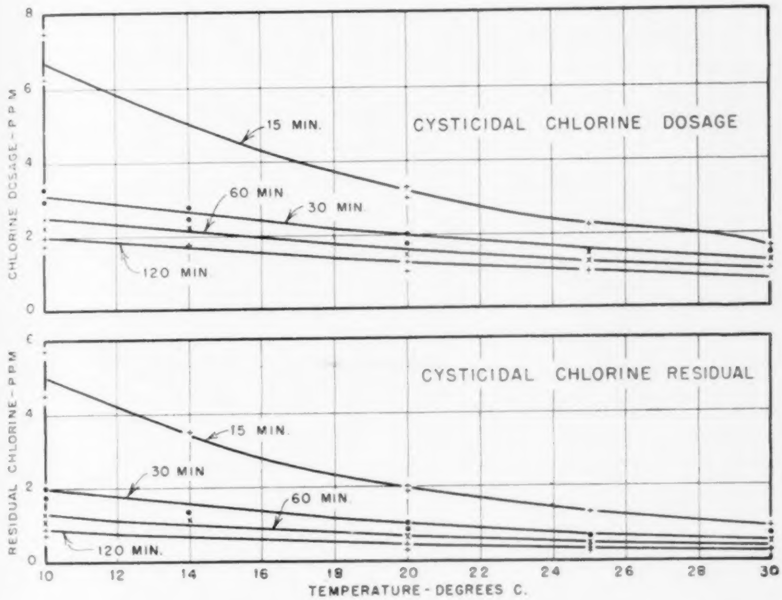


FIG. 4. Cysticidal Efficiency of Chlorine in Relation to Contact Periods and Water Temperature; cyst density varied from 60 to 100 per ml. and content of total organic nitrogen from 0.095 to 0.13 p.p.m.; residual pH was close to 7.0

strength of disinfectant employed, sometimes called the dilution coefficient.

That the 15-minute curves are so far out of line would appear to indicate that the rate of disinfection is controlled by some reaction, possibly a time lag, that becomes relatively smaller in magnitude as the time of contact is extended. If the analysis is confined to con-

tact times of 30 min. or more, the following values are obtained for the coefficients in Equations (2) and (3):

For chlorine dosage: $\theta = 1.048$, $Q_{10} = 1.6$, and $n = 3.0$.

For chlorine residual: $\theta = 1.072$, $Q_{10} = 2.0$, and $n = 1.8$.

These results imply that the cysticidal dose of chlorine is decreased by about 40 per cent for each successive rise in temperature of 10°C. (18°F.) and by about 20 per cent whenever the contact time is doubled; similarly, that the cysticidal residual of chlorine is decreased by about 50 per cent for each successive rise in temperature of 10°C. (18°F.) and by about 30 per cent whenever the contact time is

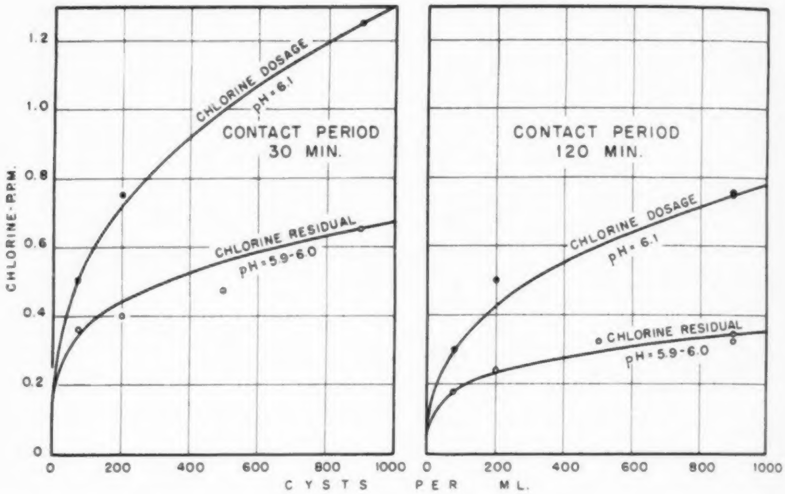


FIG. 5. Cysticidal Efficiency of Chlorine in Relation to Contact Period and Cyst Density: temperature lay at 21 or 21.5°C. and initial pH at 6.1

doubled. Required chlorine dosage, under the conditions of experiment, did not fall below 2 p.p.m. except at high temperatures or for long periods of contact. Cysticidal residuals did fall below this value and even below 1 p.p.m. under favorable conditions of exposure. It appears, therefore, that a fairly heavily contaminated water can be disinfected successfully by amounts of chlorine within the lower range of super-chlorination. This is important evidence in connection with the supply of water to troops and expeditions in regions in which amebic dysentery is particularly prevalent.

### Effects of Cyst Density

As shown in Fig. 5, the density of amebic cysts in the chlorinated water influences, to a marked degree, the concentration of chlorine required to destroy their full number. The observations here reported were confined to two contact periods (30 and 120 min.) and to a single initial pH value (6.1). The temperature was either 21 or 21.5°C. The equation of the curves chosen to fit the plotted points is:

$$\frac{D^m}{N} = \text{constant}, \quad \text{or} \quad \frac{R^m}{N} = \text{constant} \ldots\ldots\ldots\ldots (4)$$

where $N$ is the number of cysts per milliliter and $m$ is a coefficient somewhat analogous to the dilution coefficient $n$. For the conditions of test, the coefficient, $m$, was 2.7 for chlorine dosage and 3.8 for chlorine residual. Although Equation (4) only approximates, in its statement, general biological experience, it does give some numerical concept of this important factor. For each doubling of the cyst density, the cysticidal chlorine dosage would be expected to be increased by about 30 per cent and the cysticidal chlorine residual by about 20 per cent.

Related to cyst density is the concentration of organic matter in the water. This phase of the problem has, as yet, been insufficiently explored to be reported in this paper. There is no reason to believe, however, that the presence of oxidizable organic matter will affect the chlorination of cysts any differently than the chlorination of bacteria.

### Effects of pH

Of the factors evaluated in the present studies, the influence of pH was least amenable to generalization. There are shown in Fig. 6 enveloping curves of the relationship between pH and cysticidal chlorine concentration. That low concentration of required chlorine is associated with low pH and high concentration of required chlorine with high pH is well indicated. The relative similarity of the pH curves obtained for contact periods of 30 min. or more and the individualism of the 15-minute curve is again of interest. At the higher contact times there is a spread of about 100 per cent in the cysticidal chlorine concentrations between pH values of 6 and 7. Between pH values of 7 and 8 this spread is narrowed down to less than 5 per cent.

Between pH values of 8 and 9, however, it rises again to more than 20 per cent. Low pH, therefore, is favorable to the chlorination of cysts as well as that of bacteria. Studies of oxidation potential may throw additional light upon this matter.

## Summary and Conclusions

Although the experimental studies upon which this paper is based have not been brought to a close, the results that have been obtained

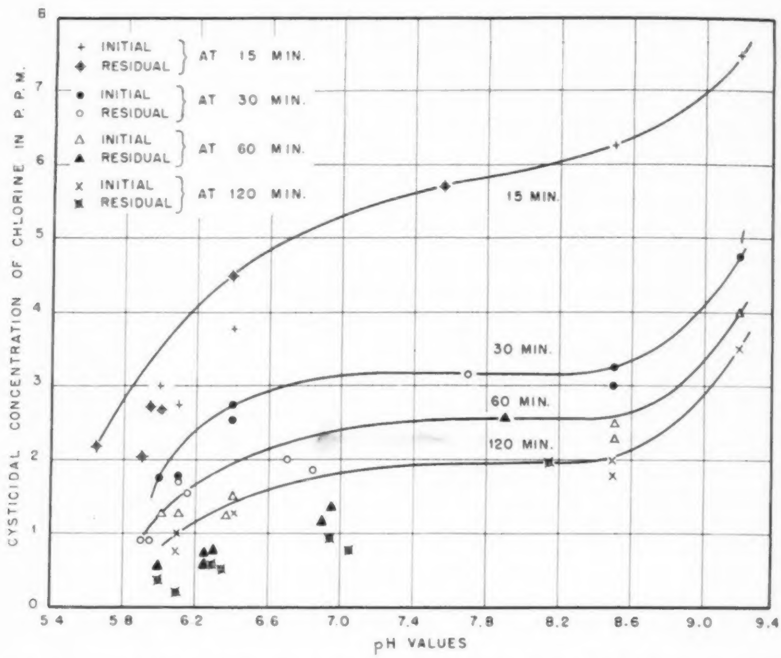


FIG. 6. Cysticidal Efficiency of Chlorine in Relation to pH value; observations were made at 10°C., with cyst density of 60 to 80 per ml. and a content of total organic nitrogen of 0.095 to 0.097 p.p.m.

so far have been analyzed in this paper in order to enable sanitary authorities to obtain, for use in the difficult days that may lie ahead, a clearer conception of some of the factors that govern the survival of the cysts of *Endameba histolytica* in water and its destruction by chlorine.

The viability of the cysts of *E. histolytica* is shown to be largely independent of water quality but greatly affected by water tem-

perature. A survival for about 90 days at freezing temperatures is reduced to 30, 10 and 3 days at 50, 68 and 86°F., respectively.

The concentration of gaseous chlorine needed to destroy the cysts of *E. histolytica* appears to lie well within the range of practicable super-chlorination, provided that the contact period can be extended to 30 min. or longer. Chlorine dosage and residuals are shown to be functions of water temperature, contact time, cyst density, and pH. Cysticidal chlorine requirements appear to be affected approximately as follows: (1) They are cut in half by a rise in water temperature of 20°F. (2) They are decreased by about 25 per cent when the contact time is doubled. (3) They are increased by about 25 per cent when the density of cysts is doubled. (4) They are cut in half when the pH value is lowered from 7 to 6, and increased by about 25 per cent when it is raised to 9. The death of colon bacilli precedes that of the cysts.

The experimental studies upon which this analysis is based are included in portions of a thesis prepared by the junior author (S. L. Chang) in partial fulfilment of the requirements for the degree of Doctor of Public Health in the Harvard School of Public Health. The work was aided in part by a grant from the John and Mary Markle Foundation. This assistance is gratefully acknowledged as is the co-operation of Dr. Ernest E. Tyzzer and the members of his staff in the Division of Comparative Pathology and Tropical Medicine of the Harvard Medical School.

# Current Activities of the Steel Pipe Committee

*By W. W. Hurlbut*

As IS well known, the object of the Association is the advancement of the knowledge of design, construction, operation, and management of water works. A step toward this goal has been made by Sub-Committee 7A in its preparation of specifications for steel water pipe and its protective coatings. To date, the Committee has made available four standard specifications: (1) for electric fusion welded steel pipe, 30 in. and over in size; (2) for riveted steel pipe; (3) for coal-tar enamel protective coatings for steel pipe, 30 in. and over in size; and (4) for coal-tar enamel coatings for steel pipe, $4\frac{1}{2}$ to 30 in. in outside diameter. Also available are three tentative specifications: (1) for steel pipe, 4 to 30 in. in outside diameter*; (2) for cement-mortar protective coatings for steel pipe, 30 in. and over in size*; and (3) for lock-bar pipe.

The future program of the Committee is one of further service. New specifications must be prepared when new materials have proved satisfactory for water works use. Tentative specifications must be revised so that they may become standard. Present standard specifications, too, must be changed from time to time as requirements change and as manufacturing methods are improved. In addition, the scope of Committee activities has been broadened to include other phases, reference to which will be made later. To accomplish this service requires a working organization, an organization to handle the large volume of work and detail. In this respect, it is most gratifying to members of the Committee that the Steel Pipe Manufacturers' Technical Advisory Committee is now a permanent organization operating under newly adopted by-laws (see Appendix, p. 1719).

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A paper presented on June 23, 1941, at the Toronto Convention by W. W. Hurlbut, Assistant Chief Engineer and General Manager, Bureau of Water Works & Supply, Los Angeles.

* Status changed from Tentative to Standard, June 26, 1941.

## History of Committee Activities

Before proceeding with the discussion of future work, it will be well here to outline briefly the history of the Committee's work. In January, 1937, the personnel of the Committee consisted of William W. Hurlbut, Chairman, William W. Brush, Fred M. Randlett, Thomas H. Wiggin, Frank A. Barbour, George H. Fenkell, and John F. Skinner. In 1940, three members of the Steel Pipe Manufacturers' Technical Advisory Committee, George McComb, Russell Barnard, and C. S. Patton, were appointed members of Sub-Committee 7A.

In May, 1937, specifications were prepared for electric fusion welded steel water pipe of large diameters, riveted steel water pipe, and lock-bar pipe. The specifications for the electric fusion welded pipe were prepared under the direction of the Chairman and were based on the standard specifications of the Bureau of Water Works and Supply of Los Angeles. Specifications for riveted pipe and lock-bar pipe were prepared from original drafts by A. R. Holbrook and F. H. Stephenson. In March, 1938, the first draft of standard specifications for protective coatings for steel water pipe was transmitted to members of the Committee. In April, 1938, at the New Orleans Convention, several steel pipe manufacturers met with members of the Committee to suggest revisions to these specifications. During that year, two revisions were made in the specifications for electric fusion welded steel pipe.

Again at the Atlantic City Convention in June, 1939, a number of steel pipe manufacturers met with the Committee for several days. As a result of these discussions it was decided that it would be mutually advantageous for the Committee and manufacturers to meet at a later date for further discussion. Thus, was sown the seed for an organization later to become the Steel Pipe Manufacturers' Technical Advisory Committee.

The meeting proposed was held in Chicago in September, 1939, and was attended by a number of the steel pipe manufacturers, manufacturers of protective coatings, and members of Sub-Committee 7A. At this time it was suggested that the group of manufacturers form a permanent organization to act as an advisory body to the Committee and to perform other related work. After a week of intensive discussion, specifications for electric fusion welded steel pipe and for coal-tar enamel protective coatings for steel pipe, 30 in. and over in size, were completed. Work was commenced too on the specifications for electric fusion welded pipe of 4 to 30 in. in outside diameter, and

last year at the Kansas City Convention, tentative specifications were completed.

### Work of Technical Advisory Committee

Today, the Technical Advisory Committee is an established organization, operating under by-laws, with a membership consisting of individuals representing organizations engaged in the manufacture of steel pipe, steel pipe appurtenances, and steel pipe protective coatings. The officers of this Committee consist of a chairman, H. R. Redington, and secretary, Walter Cates. In addition, there is an executive subcommittee of five members, which include the chairman and secretary. The committee work at present is allocated to five other sub-committees (see Appendix, p. 1719). As stated before, to accomplish the work of Sub-Committee 7A, a working organization is necessary. In the Technical Advisory Committee that end is realized.

A proper attitude toward preparation of new specifications must be adopted. From time to time new materials will be developed for which it will be necessary to prepare specifications. These materials should be used for a definite time, and their utility and tendency toward long life proved, before standard specifications are written. For instance, electric fusion welded steel pipe has now become a standard article. It was not until 1936, however, that the first A.S.T.M. standard specifications for this type of pipe were written. Another example is the new plasticized coal-tar pitch enamels which were placed on the market in 1933. The A.W.W.A. specifications covering coal-tar protective enamels for steel pipe were not adopted and made standard until 1940, an interval of seven years. It is believed, therefore, that, in connection with new materials, especially protective coatings, an interval of at least five years, as a period of consideration and trial, should be allowed prior to the final adoption of specifications.

The Sub-Committee on Technical Standards of the Advisory Committee has outlined a program for future work which will be of inestimable value to the water works field. Its program includes a compilation of lists of steel pipe installations. The history of steel pipe installations in this country will be of great value, inasmuch as it may ultimately serve as a document to aid in determining depreciation rates of steel pipe.

Establishing methods of designing and reinforcing steel pipe fittings is a subject of much interest to the water works field. A standard method of solution of this problem will cut down much guess work

that has been done in the past in regard to reinforcing fittings. The importance of standardization of dimensions of steel pipe fittings cannot be minimized. It should include studies of the proper size of reducers, from the standpoint of economy. Standardization of the thicknesses of flanges for steel water works service has also been the subject of investigation by this sub-committee.

The design of steel pipe and the determination of steel pipe thicknesses to resist internal pressure and external loads presents another opportunity for Committee service. These and other subjects indicate the scope of activities of the Technical Standards Committee.

Among the duties of the Sub-Committee on Meetings is co-operation in the setting up of a program for the convention of the subsequent year. By a system of long range planning for these programs, papers requiring considerable research may be completed in ample time for the next convention.

## Appendix

### Rules and Regulations of the Steel Pipe Manufacturers Technical Advisory Committee

*Rule I—Name*

The name shall be the "Steel Water Pipe Manufacturers Technical Advisory Committee."

*Rule II—Purpose*

The purposes for which this Committee is organized are:

1. To co-operate with the Steel Plate Pipe Committee of the American Water Works Association.
2. To improve the research, engineering and manufacturing processes in connection with the production of steel water pipe.
3. To collect and disseminate technical information concerning steel water pipe. All statements related to the activities of the A.W.W.A. Committee on Steel Plate Pipe shall route through that Committee and are subject to the limitations upon such matters as are laid down in the "By-Laws of the American Water Works Association.

*Rule III—Duration*

The Committee shall continue until such time as:

1. It may be dissolved by a vote of two-thirds of its members.

2. The Board of Directors of the American Water Works Association may consider that its functions have been completed.

*Rule IV—Headquarters*

The headquarters of the Committee shall be located in the office of its Secretary.

*Rule V—Membership*

Membership shall consist of individuals representing any organization engaged in the manufacture of steel water pipe, steel pipe appurtenances or steel pipe protective coatings, provided said individuals:

1. Represent organizations having Associate Membership in the American Water Works Association; or

2. Are Active Members of the American Water Works Association.

*Rule VI—Membership Applications*

All applications for membership must be made in writing to the Secretary. Upon approval of an application for membership by a majority of the Executive Committee, the applicant shall become a member of the Committee. Formal notices of acceptance shall be given by the Secretary.

*Rule VII—Organization*

A. The officers of the Committee shall consist of a Chairman and a Secretary. In addition thereto there shall be an Executive Committee of five members including the Chairman and Secretary. The Chairman of the Committee shall be Chairman of the Executive Committee.

B. Officers and members of the Committee and the Executive Committee shall hold office for three years following the 1941 Annual Convention Meeting of the American Water Works Association or until their successors have been duly chosen and qualified. When this initial three-year period has expired, two-thirds of the membership shall be replaced, in order that each Committee will always have experienced personnel.

C. The Steel Water Pipe Manufacturers Technical Advisory Committee may have such sub-committees as are necessary to deal with the various subjects related to steel water pipe, its installation and protection. The following sub-committees are active at the present time:

1. Sub-Committee on Large Steel Pipe (30 in. in diameter and over)
2. Sub-Committee on Small Steel Pipe (under 30 in. in diameter)
3. Sub-Committee on Protective Coating Specifications
4. Sub-Committee on Technical Standards
5. Sub-Committee on Meetings

Other sub-committees may be appointed from time to time. Appointment of sub-committees shall be made by the Chairman with the advice and approval of the Executive Committee.

*Rule VIII—Duties of Committee and Executive Committee*

A. The Committee shall fill by appointment all vacancies that may occur for unexpired terms.

B. The Executive Committee shall have the general management and control of the affairs of the Committee during the time when the Committee is not in session.

*Rule IX—Duties of Officers*

The Chairman shall preside at all regular and special meetings of the Committee and, as an ex-officio member of each, shall have an equal voice with other members of the Committee and the Executive Committee. In the absence of the Chairman, the Secretary shall act as Chairman *pro tem.*

The Secretary shall keep all records of the Committee and perform such other duties as shall be prescribed from time to time by the Committee.

*Rule X—Election of Officers*

A. At each annual meeting of the members of the Committee, the officers shall be elected by ballot.

B. The election of the officers and members of the Executive Committee shall be preceded by a period of nomination.

C. The Secretary shall forthwith prepare a ballot on which shall be placed in alphabetical order all the names proposed for election.

The election shall be held not later than the third day sessions of the American Water Works Association Annual Convention. The candidates receiving the highest number of votes from members shall be declared duly elected.

D. In case only one candidate is nominated for each vacancy, a voice or rising vote may be taken.

*Rule XI—Meetings of Committee*

The annual meeting of the Committee shall be held each year at the call of the Chairman during the Annual Convention of the American Water Works Association. The time and place of other general meetings will be determined by the Executive Committee.

*Rule XII—Quorum*

At all meetings, regular or special, of the Commitee a majority of its members shall constitute a quorum.

*Rule XIII—Withdrawals*

Any member of the Committee who desires to resign may do so by writing to the Secretary.

*Rule XIV—Order of Business*

The order of business at all meetings of the Committee shall be as follows:

1. Roll call
2. Reading of minutes of previous meetings
3. Chairman's remarks
4. Reports of Secretary
5. Other reports
6. Consideration of communications to the Committee
7. Unfinished business
8. New business
9. Election of officers (at annual meeting only)

*Rule XV—Amendments*

These Rules and Regulations may be amended by a majority vote of all members present at any annual or special meeting of the Committee. These Rules and Regulations and any amendments thereto are subject to the approval of the A.W.W.A. Board of Directors.

# Mechanical Application of Bituminous Pipe Coatings and Linings

***By Laurance E. Goit***

PITCHES have been used by man throughout the ages to serve his purposes in waterproofing or preserving many things. It is reputed that Noah's Ark was calked with pitch. The reed basket in which Moses was hidden was daubed with pitch to make it waterproof so that it would serve as a small boat. It is probable that Noah used vegetable pitch such as exudes from pine and fir trees, but asphaltic mineral pitches were known to the Egyptians and were put to many uses, including the preservation of mummies.

The use of pitch for corrosion prevention brings us to relatively modern times. Early cast-iron pipes for water works were not coated in any way. It is probable that troubles from the products of corrosion first indicated the need of a lining. About 90 years ago, then, pipe was first dipped in coal-tar varnish (1) to prevent tuberculation on the inside, the coating on the outside improving its appearance.

Bituminous pitches used for modern pipe lining and coating are often thought of as minerals out of the ground, but all are of organic origin. Many forms of asphalt have, in the past, been used, compounded and blended to various formulas. Among these were Gilsonite, Trinidad asphalt, and petroleum asphalt. In many places, local oil seepages supplied pitch of a consistency that required little or no heating for application by daubing. Such material was used in Los Angeles in the 1870's on sheet-iron pipe. The usual method of application, however, was dipping in a trough of melted asphalt. This permitted the application of relatively uniform linings inside pipe of any size, as well as coating the outside.

Coal-tar varnish has long been used as a dip for cast-iron pipe. It has usually been indifferently specified and carelessly handled in the

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kettle. The coating produced is frequently too thin and brittle, though occasionally a lot of pipe has come through with moderately thick and tenacious coating. Continuous heating of coal tar with occasional additions of fresh tar is not practical because distillation and coking soon spoils the batch. Thinning with oils cannot restore the elastic qualities possessed by freshly melted tar. Thus are produced the poor coatings observed on dipped cast-iron pipe, when kettles are operated continuously.

For many years coal-tar enamels have been made from pitch with inert powdered fillers. Such enamels cannot be applied successfully by dipping. Early applications of lining were made by mopping and daubing. Centrifugal casting of linings was first successfully carried out with cast-iron pipe in England and then in America. Development of equipment for lining steel pipe in long lengths and large sizes was started by one of the leading manufacturers of bituminous enamels in about 1930. Credit is due the manufacturers of coal-tar materials for continuous development of ideas and for the great assistance given to those who later built permanent cleaning and application plants, such as that of the Bureau of Water Works & Supply of Los Angeles (2).

## Factors Included in Specifications

In 1930, specifications for coal-tar enamel were rather sketchy and tests to be applied to insure delivery of enamel of uniform quality were entirely missing. Through the co-operative effort of various manufacturers and users, specifications (3) and tests were developed, and this effort culminated in 1940 in the adoption by the American Water Works Association of comprehensive specifications for coal-tar protective coatings (4).

The ingenuity of the mechanical engineers of various pipe fabricators was challenged by the problems developed in the operation of the first plants. Certain principles had been proved and constants established, such as surface speeds and thickness, but many peculiar and sometimes unanticipated problems arose. Different plants found that their own location and surroundings introduced factors not encountered elsewhere. This accounts for the variety of different solutions for carrying on similar operations.

Climate plays an important role. The prevalence of wet weather —rain, fog, high humidity—has influenced some layouts. Other factors to be considered are smoke and dust as a nuisance to nearby

residences, the range of diameters and lengths of pipe to be provided for, the shape of the available space in which the plant can be built, the source of power and fuel, and the pipe handling facilities.

## Cleaning and Priming Methods

Engineers have found that it is practical to apply protection to a clean surface only, and recognize that blasting is the best and most economical method for thorough cleaning.

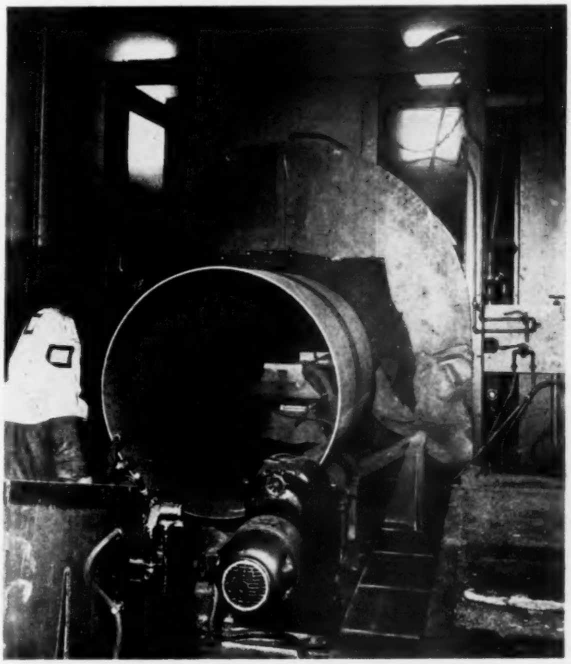

FIG. 1. Shot-Blasting Machine

The blasting mediums used are sand, chilled shot, and chilled steel grit. All of these must be kept dry, and the air used for the blast must be low in humidity to avoid condensation in the nozzle. Therefore, most permanent blasting plants are well housed (Figs. 1 and 2) and are equipped to remove dust and recover the grit for re-use. When new pipe is being blasted with shot or grit relatively little dust is produced and that dust is very heavy so it does not travel far. The maintenance of a clean blast and the removal of dust and wastes from

the salvaging of used pipe presents serious problems not encountered when processing new pipe.

Most hot enamel coatings are applied over a bonding primer. The primer is a cold paint consisting, in general, of the same pitch base as the enamel to be used, cut back with solvents. The material is sometimes heated to about 100° F. to increase its fluidity for spray application.

Coal-tar enamel has been applied very successfully without the use of primer, by heating the pipe moderately and uniformly (5). This step in lieu of priming avoids the storage of quantities of pipe while

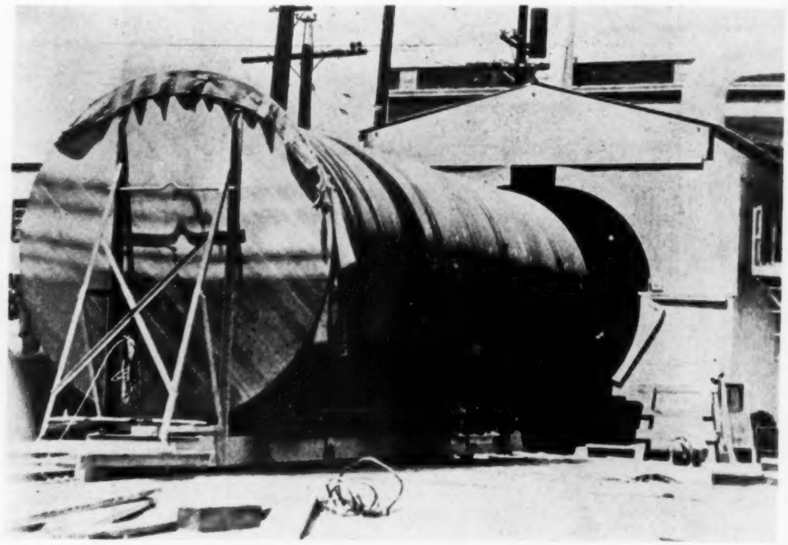

FIG. 2. Enclosed Blasting Equipment

primer is drying, but introduces a step that must be nicely controlled for uniform results.

## Lining Methods

The application of coal-tar linings to pipe of all sizes is the most difficult operation in complete protective coating, and several distinct types of equipment have been developed for distributing hot enamel to inside surfaces. One factor common to all is the use of centrifugal force for spreading and smoothing the lining. The variations in method of getting the enamel on the surface are:

1. End dams and pool, for small pipe
2. Double troughs, entering one from each end
3. Single trough, entire length in one pour
4. Retractable nozzle, usually used for small diameter pipe
5. Retractable weir, for larger pipe

In Method 1 rings or dams are placed in or against the ends of the pipe. Then with the pipe on the spinning rolls, but not turning, a measured quantity of enamel is poured into the pipe. When the spinning rolls are level, a pool of enamel of uniform depth lies in the bottom of the pipe. As soon as this pool is leveled off, rotation is started and, after a few turns to wet the entire surface, spinning speed is accelerated to that required to hold the fluid enamel on the pipe and spread it smoothly, continuing until the enamel cools and sets.

This is the first method devised for getting the enamel distributed throughout the pipe for centrifugal application. It was developed under hot dry weather conditions and its use was limited to those conditions when the metal of the pipe was hot, unless preheating of the pipe was resorted to, which became a more expensive method than those later developed. The method is now obsolete since the results produced were not up to present-day standards.

The use of two troughs is an early development in lining application which is still in favor. The Los Angeles water bureau's plant (2) uses two troughs, each 15 ft. long, to line 30-foot lengths of pipe. A plant has been completed recently at Homestead, Fla., using two 25-foot troughs for 50-foot lengths of pipe. The space occupied is compact but requires room on each side of the main runway for track extensions for trough cars and melting kettles. Also space must be available on each side for storing and breaking up enamel for the kettles.

The troughs at Los Angeles (Fig. 3) are advanced and withdrawn by hand. The tracks are carefully leveled and screw adjustment of the rear trough trunnion bearing permits leveling of the trough. In some plants the counterweighted trough cars are propelled by power through chains.

In using double troughs, both are entered, one to its full distance and the other incompletely. The first is dumped and withdrawn and the second immediately moved in, and dumped quickly, to be sure the coating joins in the center.

The size of the trough with supporting boom for the short half length trough is small enough for use in pipe as small as 16 in. in

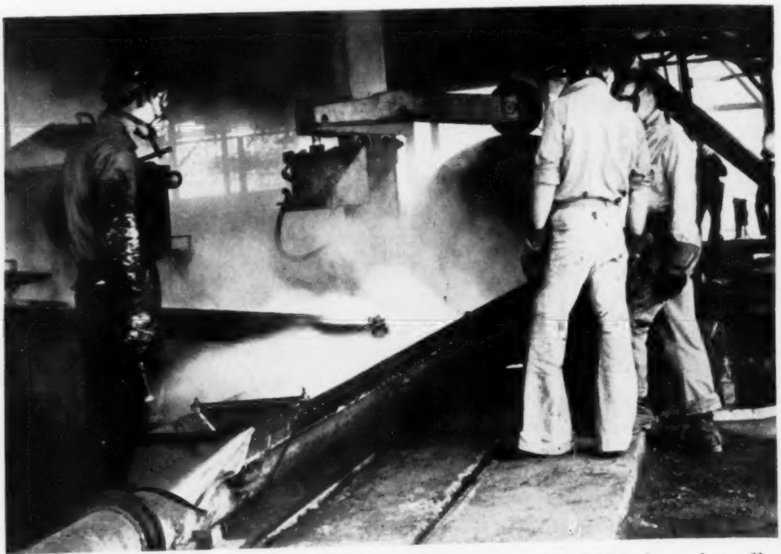

Fig. 3. Enamel Trough Being Filled; showing pipe being held down by roller on beam

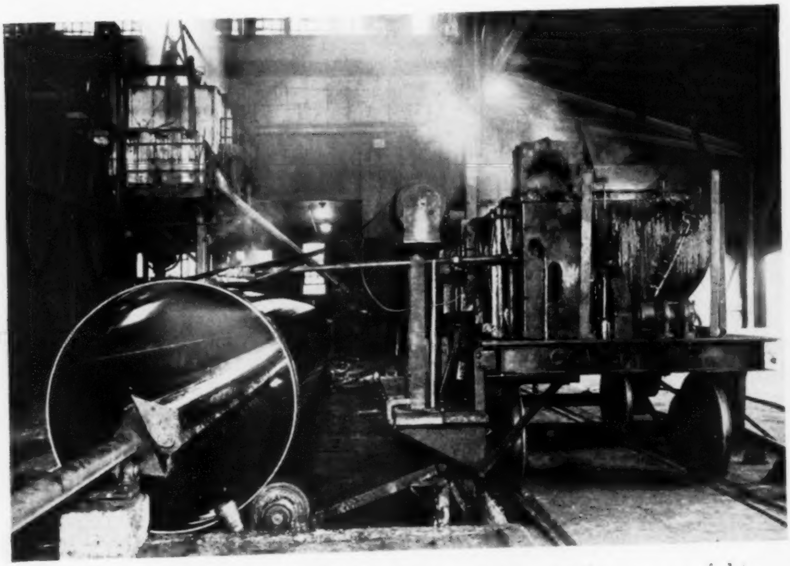

Fig. 4. Single Trough in Pipe; showing outside coating car on right

diameter. The maximum size is controlled by other plant conditions, and in the Los Angeles plant is 60 in.

Where a single trough is used, a complication is introduced by the flexibility of the long trough. Figure 4 shows the back end of typical single trough equipment. In the left foreground is seen a counterweight boom which is attached to the trough when part way through the length of the pipe, and which is pushed back by the trough, supporting and steadying the end of the long trough and maintaining the pouring lip level.

The principal part of the operations in the lining plant using a single trough is carried on at one end of the pipe and the melting kettles are concentrated there. The trough carriage track is somewhat longer than the pipe to be processed, and the counterbalance boom requires nearly as much length. Therefore, the entire space required is about three times the pipe length.

Long single troughs are usually bulkier than short troughs, and require pipe of 24-inch diameter and larger for fast safe use. Pipe up to 96 in. in diameter has been lined by the use of a single trough (Fig. 9). This size pipe is the approximate practical maximum for this method because of the heavy load of liquid enamel in the trough.

In plants using the retractable nozzle, very small pipe can be lined with perfect assurance of success. One such nozzle is shown in Fig. 5. Enamel is pumped from the kettle on a traveling car through the feeder line to the nozzle, where it is spread on the bottom of the rotating pipe. The nozzle is slowly drawn through the pipe at such a speed that the pitch of the spiral of enamel laid down is only a fraction of the spread from the nozzle. This results in the application of two or three layers of enamel and their amalgamation into one smooth lining. Most plants using this method start with the nozzle at the far end of the pipe, hence the expression "retractable nozzle." Linings are applied to pipes as small as 2 in. and up to 30 in. in diameter by this process.

Very large pipe can be lined most successfully by the use of the retractable weir. In Fig. 6, the boom through the pipe has a weir box on the near end. Enamel is pumped through a pipe on the boom into the weir box where it is spread out into a uniform sheet as it pours out on the pipe surface. As the boom with the weir is withdrawn a spiral of enamel is applied in overlapping layers and immediately smoothed by the centrifugal force. At least one plant, however, starts coating at the near end of the pipe.

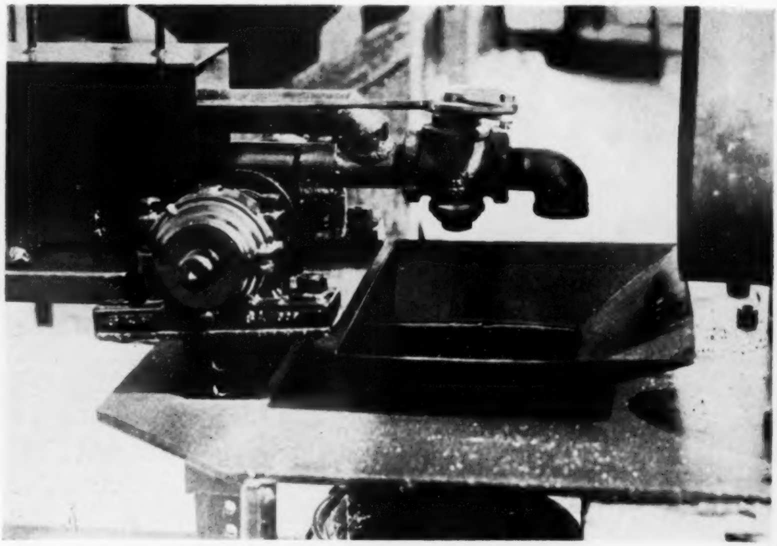

FIG. 5. Lining Nozzle and Return Pipe

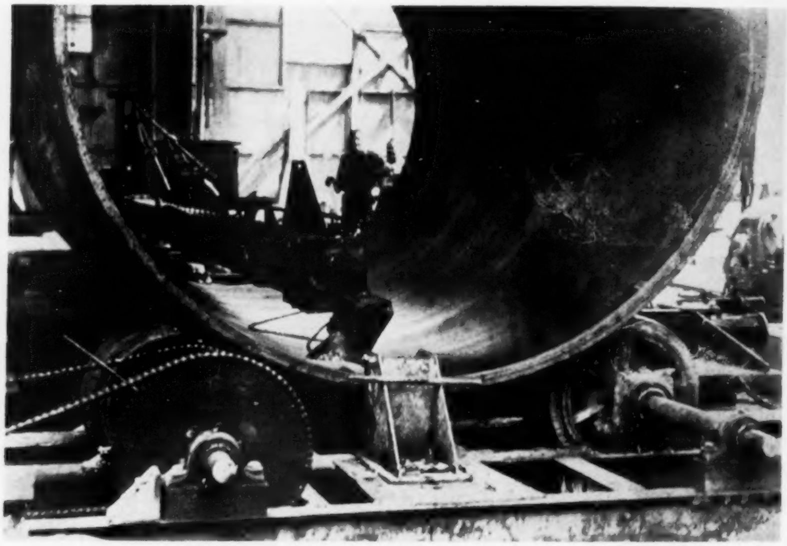

FIG. 6. Boom with Weir in Pipe on Spinning Machine

## Outside Coating Methods

The application of enamel coatings to pipe is accomplished by various devices all of which pour enamel on the pipe and spread it with a suitable drag (Fig. 18), a spiral path being followed along the revolving pipe. The spread of the pool of enamel is usually two or three times the lead of the spiral so that the full coating thickness is made up of several layers, thus reducing flaws to the vanishing point.

The majority of coated pipe is also wrapped. The most popular wrapper is asbestos felt saturated with bitumen. This is applied

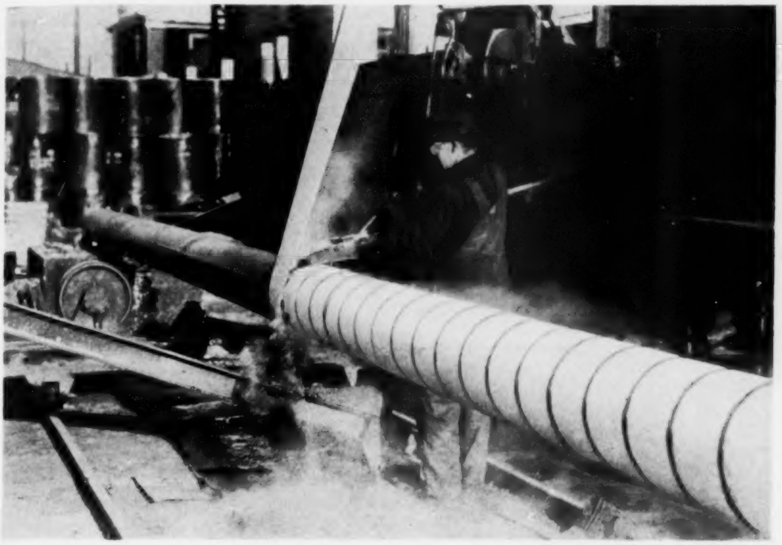

FIG. 7. Application of Bonded Wrapper to Long Pipe

spirally as shown in Fig. 7 and bonded to the pipe by flooding with enamel. Multiple layers of the felt may be applied and it is usual to finish with an unbonded wrapping of heavy paper for extra protection in handling and shipping.

## Plant Layout

There are as many plant layouts as there are plants. The plant of the Bureau of Water Works & Supply in Los Angeles (2) is fairly close in layout to the ideal, where pipe progresses from the receiving of raw pipe to the storage of finished pipe through the various proc-

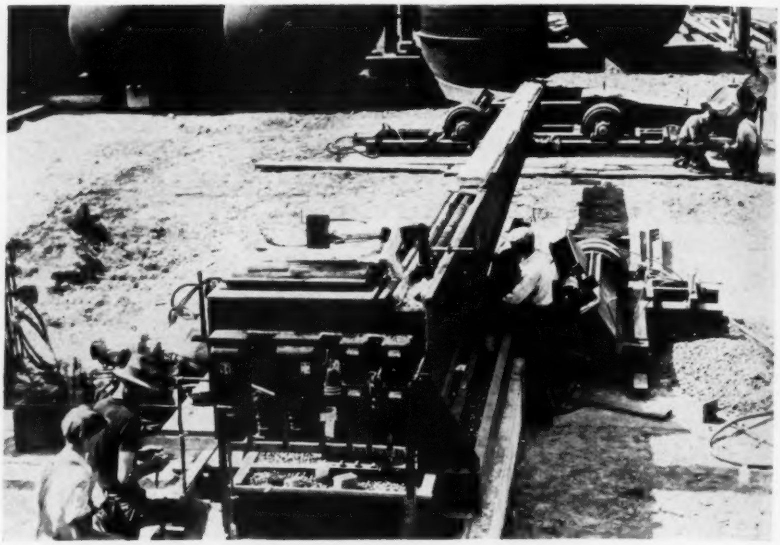

FIG. 8. Set-Up of Spinning Machine and Lining Car with Boom

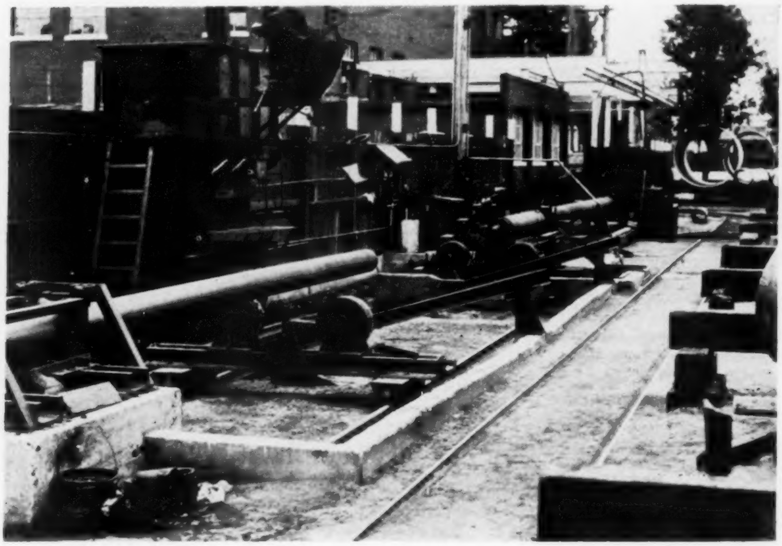

FIG. 9. Long Single Trough in background with End-Supporting Boom in foreground

esses, without lifting or turning or excessive handling. The processing takes place along a straight line, but if a considerable quantity of pipe is to be stored at each end it must be handled by cranes from and to storage runways.

The designer must usually make the plant fit the space available, giving consideration to climate, shop or yard cranes, railroad facilities, existing buildings, and many other factors. The prevalence of fog and raw weather made it expedient for one plant to be provided with a warming oven at the start of the line. The above factors may influence the choice of variations in methods and equipment described herein.

If we visualize a plant with straight line progress of the pipe along runways, we shall see how methods and space are interlocked. Blasting by mechanical methods requires axial travel of the pipe for a distance equal to the length of the pipe, and equipment, housing, working space, etc. increase this space required transverse to the direction of the main runways. Priming the inside with a circular spray nozzle also requires transverse space equal to the pipe length and this can be beside the blasting equipment. The two-trough method of enameling the inside requires space on both sides of the main runway, with kettles, etc., as described. The single trough method requires the greatest extension of plant on both sides of the main line but the kettles can be kept on one side. The retractable weir and nozzle methods require practically no extension of plant on one side and no more on the working side than the other operations. Outside coating equipment works beside the pipe and requires space only to clear the runways for changing pipe.

## Blasting Equipment

Efficient operation of a pipe blasting plant requires the use of continuous blasting machines and mechanical return of the blasting medium to the machines for recirculation. Figure 1 shows a shot-blasting plant in which the pipe rotating on a traveling carriage moves past batteries of nozzles on the inside and outside. This feature is common to a number of plants but details are varied. In the figure, it should be noted that the operator riding the car is wearing a protecting hood. No effort to collect dust is made because only new pipe is processed there. A hood encloses the outside nozzles causing the spent shot to drop into a hopper in the floor. The inside nozzles are carried on a boom that extends into the pipe, and spent shot is

collected by the hopper in the pipe to be dumped at the completion of the length. The inside hopper is very convenient for pipes of about 18 to 36 in. in diameter. Construction of a hopper for smaller pipe is difficult, and the load of shot accumulated from larger pipe presents serious problems.

Where blasting is performed in a small tight room as illustrated in Fig. 2, grit can be permitted to fly. In the Los Angeles plant a complete enclosure has been built and the pipe axis is slanted slightly,

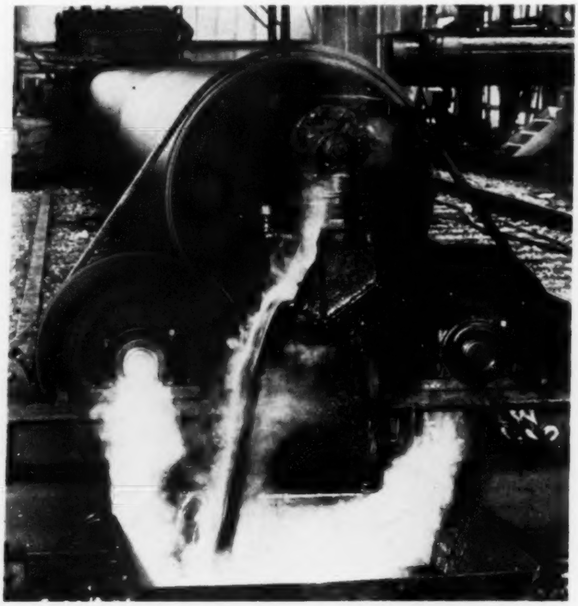

FIG. 10. Pipe Spinning and Enamel Flowing from Weir ready to be drawn into pipe

causing the grit to pour out of the lower end. This and the grit from the outside nozzles must be swept into a hopper, from which a bucket elevator raises it above the blasting machines. In one plant, pipe is up-ended by a crane to remove grit from the inside. Another plant has a full length hopper floor with a screw conveyor operating in a channel in the bottom, to convey the grit to a bucket elevator.

Some plants use small round chilled-iron shot as a blasting abrasive and others use grit which is produced by crushing larger chilled shot. Both do an excellent job of removing rust and mill scale. The grit

produces a finely jagged or toothed surface and the shot leaves a finely pebbled surface.

Even when working on new pipe that has only mill scale to be blasted off, there must be some removal of dust. The fine dust from the blasted surface and the wear of the abrasive will greatly reduce the efficiency of the blast if allowed to accumulate in recirculating the grit or shot. It has been found that a moderate stream of air directed across a falling stream of grit can be adjusted to blow out dust or fines to any degree desired. A very necessary part of the grit recovery system is a screen that will arrest any matter that will not, later, pass through the nozzles.

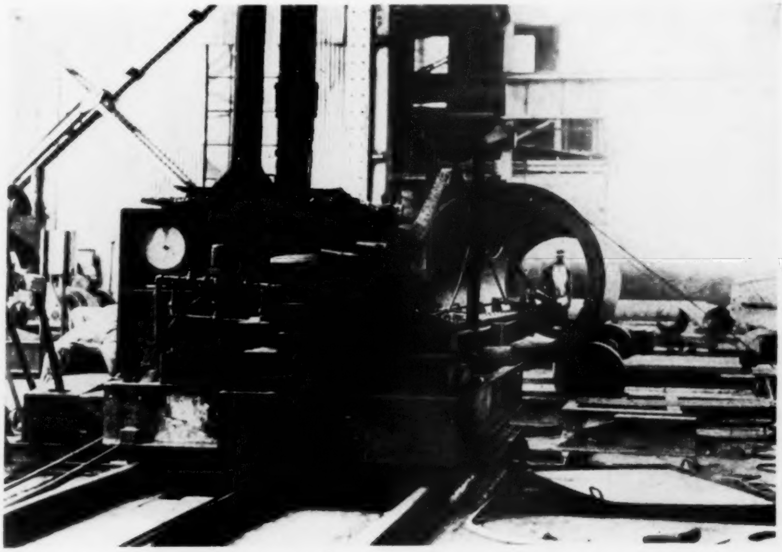

FIG. 11. Lining Car with Boom, ready to apply lining by Weir Method

The majority of plants that are housed as in Fig. 2 use powerful suction fans with various ordinary types of dust collectors and have good results in removing dust that otherwise would impair the efficiency of the blasting, or would be carried by wind to become a nuisance. In Los Angeles considerable footages of salvaged pipe including cast iron and steel have been reconditioned. All of this pipe is encrusted with barnacles on the inside and dirt on the outside. The friable material does not present any problem except removal of dust, but considerable amounts of old dip are encountered frequently.

When the temperature is high this is extremely hard to remove and when removed is sticky enough to interfere seriously with the free flow of the grit. No satisfactory solution to this latter difficulty has been found. It is avoided as much as possible by hand scraping to remove most of the old coating and blasting in early cool hours when the bitumen is brittle.

Pipe is sometimes blasted by hand-held nozzles. In one plant large pipe is blasted on the inside by a man holding the nozzle and walking in the pipe as it is rotated at a suitable speed. Fittings and special parts must be blasted by hand, and in such cases, a walled en-

FIG. 12. Lining Car with Air-Heated Boom

closure with a good floor makes possible the complete recovery of the sand or grit.

### Priming Equipment

The application of primer is essentially a hand operation. Priming is the fastest operation in the production line, and the men engaged have time to blow off thoroughly all dust resulting from blasting.

The interior of pipe up to 60 in. in diameter can be primed by the use of a special air atomizing nozzle that throws a 360-degree radial fan of primer. Such nozzles are fully adjustable for the quantity of material discharged, proportions of air to material, and fineness of

atomization, so that the same nozzle can be used for 4- or 60-inch pipe. Some plants supplement the spreading of primer from the spray by brushing with bristle brushes on a rotating arbor or by rotating the pipe. The benefit claimed for the brushing operation is the more complete coverage of the metal with penetration into rough surfaces. Pipe larger than about 60 in. in diameter is usually primed on the inside surface by hand-operated air brushes. Like the blasting of large pipe, it is practical to rotate the pipe slowly while the painter walks inside, spraying a spiral through the pipe. The priming of a 6-foot pipe, 30 ft. long, by this method gives the man a 1,000-foot

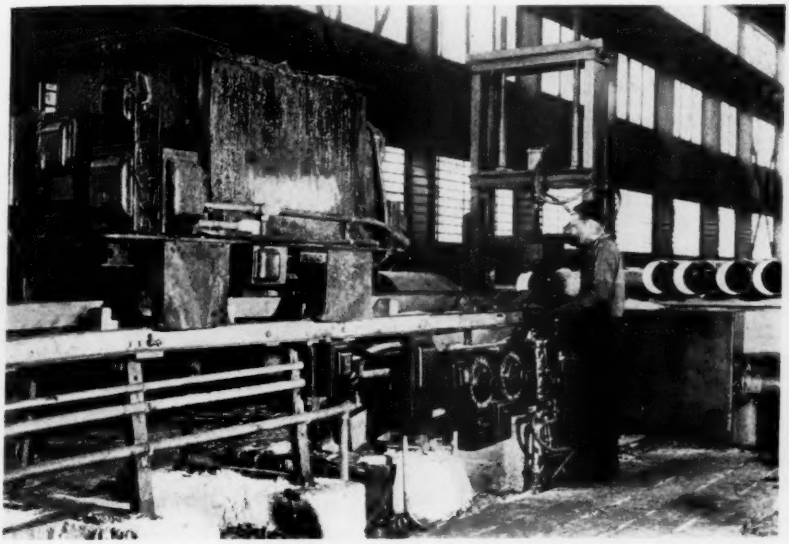

FIG. 13. Operator's Station and Lining Car with Kettle

walk at a very uniform pace and takes about five minutes. The circular spray nozzle coats the inside of any pipe within its range in about 30 seconds.

Priming of the outside of pipe is done with hand-operated air brushes. The operator is sometimes helped by rotating the pipe mechanically but usually he coats about a quarter of the circumference for the full length and rolls the pipe to place another quadrant in a convenient position.

The drying period recommended by different manufacturers of pipe line enamels varies a little, but, in general, successful bonding of the enamel is obtained at any time from 6 to 24 hours after priming.

For spraying primer either with the circular spray nozzle on the inside or hand-operated air brush on the outside, the primer is contained in a regular pressure paint pot with pressure regulators, continuous agitator and a water bath for heating the contents when necessary. Care must be taken to supply dry air to the pressure pot and to the atomizers.

### Pipe Spinning Equipment

To spin heavy pipe at peripheral speeds of 1,000 ft. per minute requires carefully designed heavy equipment with high factors of

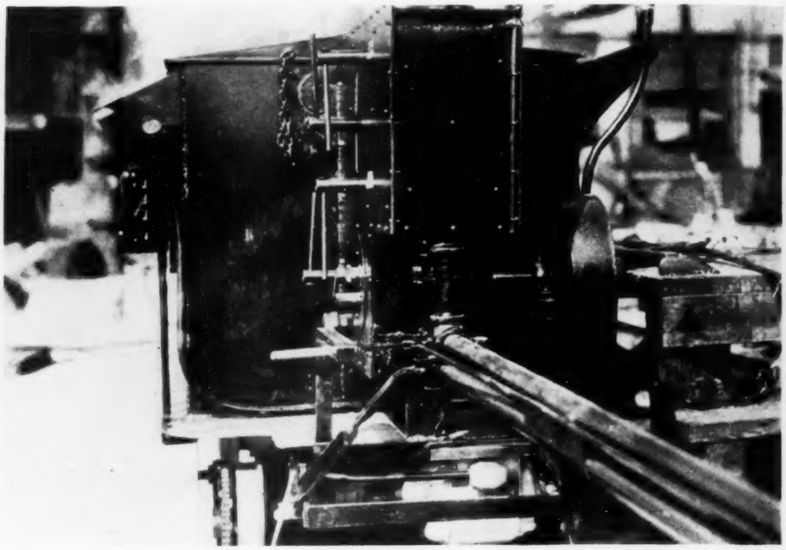

FIG. 14. Lining Car with Nozzle Feed and Return Pipes

safety. For power both gasoline engines and electric motors are used.

Gasoline engines have great flexibility in speed and, with an automobile type of transmission, very rapid acceleration of the mass of the pipe can be obtained. Exhaust gases must be piped outside of a building or enclosure. If the plant is not housed, disposal of the exhaust must be made so the men will not be exposed to its toxic effect.

Electric motors used are usually alternating current machines with fixed speeds. This forces the introduction of variable speed transmissions which are usually of the variable V-pulley and belt type.

Three-phase motors are easily reversed, and reversing direction of rotation may be desirable when pipe is wrapped.

The drive from the prime mover to the pipe rolls is made through V-belts or roller chains. The belts are much quieter than the chains and are capable of absorbing shocks and vibrations, thus lessening the stresses on all parts. The driving chain is plainly visible in Fig. 6. There is no uniformity in location of the driving rolls. In some plants they are at the end of the pipe nearest the principal operating side of the line, and in others at the far end.

The rollers on which the pipe is spun are universally equipped with

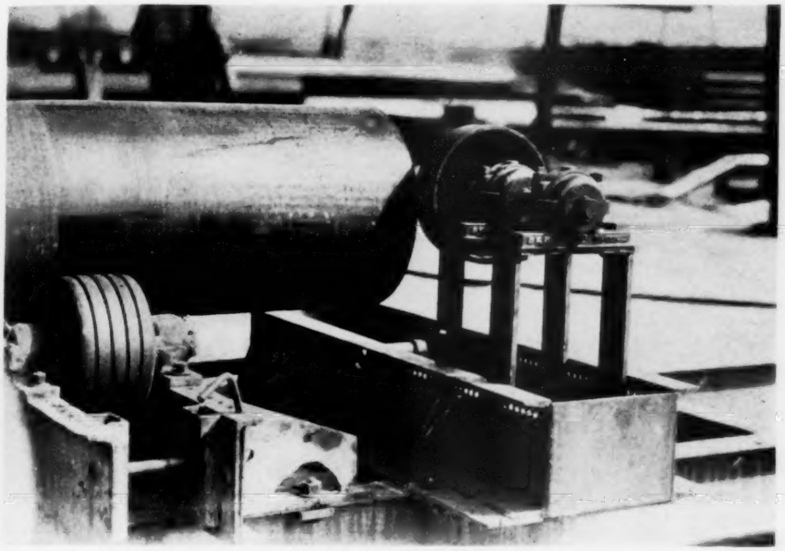

FIG. 15. Idling Roller End of Spinning Machine

solid rubber tires. A wide variety of diameters and tread widths are available in industrial tires on demountable rims. The manufacturers' load ratings for tires are for loading against flat floors and must be very conservatively used for loading against rounded pipe surfaces. Bearings used are of various anti-friction types of very rugged construction, with dust-excluding rings. Figures 4, 8 and 15 show considerable similarity in layout of rollers and mountings.

Adjustment of distance between the two rollers of a pair is necessary for handling different diameters of pipe. This complicates arrangements for driving both rollers, but such a drive is desirable

because the slip is great when only one roller is driven, resulting in rapid wear of the tire and time lost in accelerating the pipe.

The idling pair of rollers is built and mounted like the driving pair, but in most plants is movable as a unit to adjust for various lengths of pipe. Figure 8 shows a plant during process of construction, where the driving rolls with electric motor and variable speed gear are in the background. This driving unit as a whole can be moved toward the foreground to accommodate various lengths of pipe, while the idling rolls are fixed in position.

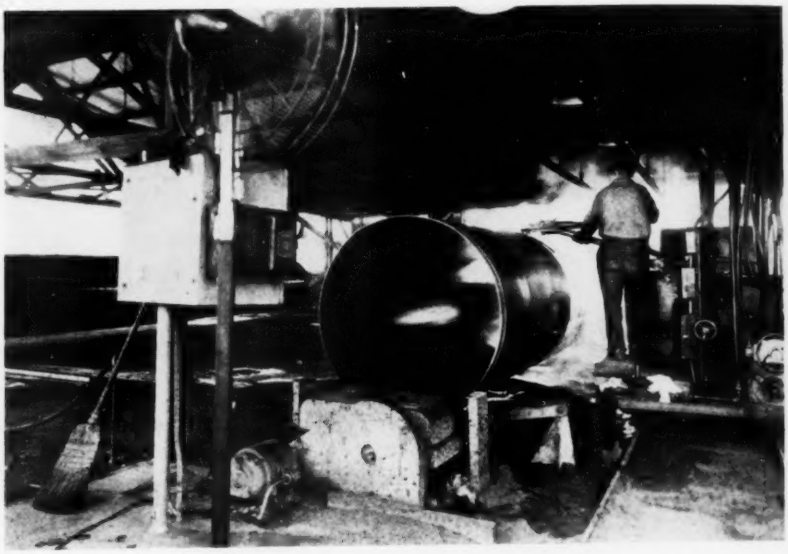

FIG. 16. Driving End of Coating Equipment with Coating Car

To keep the pipe from traveling endwise due to imperfections in leveling and lining up rolls, adjustable end-stops are necessary. The rolls in Fig. 10 have flange plates bolted to the rubber-tired wheels for this purpose. In Figs. 4 and 6, small diameter rollers with hard steel faces are adjusted to the end of the pipe. These small rollers sometimes upset burs on the pipe ends. One of the newest plants, shown in Fig. 15, uses a large diameter wheel for an end-stop, resulting in less wear on the tread of the wheel and very little burring of the end of the pipe.

In the centrifugal casting of the enamel lining, high rotational speeds are attained and the danger that eccentricity of the pipe or

high weld beads will throw the pipe off the rolls is always present. Several retaining devices are used. In Fig. 10 can be seen a strap of steel curving over the pipe, but not contacting it. Hinged at one end and locked down at the other, this device is very effective in retaining the pipe in position. Each size of pipe requires a separate pair of straps. Various methods of mounting a rubber-tired hold-down wheel are used. The frame just over the operator's head in Fig. 13 forms guides for a hold-down wheel that is adjusted by the two long screws. In this plant it is necessary to maneuver the pipe endwise

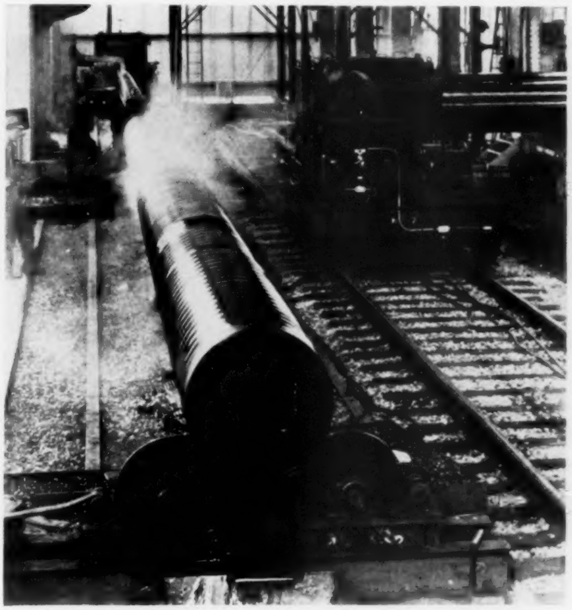

FIG. 17. Coating and Lining Set-Up on Same Spinning Equipment

into the frame, after which the air cylinder maintains a pressure on the wheel. This equipment handles pipe up to 30 in. in diameter and up to 50 ft. in length. A variation of this hold-down is shown in Fig. 3. The arm in the top center of the picture sets diagonally so that pipe can be rolled past the post on which it is mounted. The entire arm can be moved up and down the post for various sizes of pipe and the hydraulic cylinder shown is used to press the safety roller against the pipe or raise it clear as required. One plant uses steel cables drawn over the pipe and secured. Each of these various devices is duplicated at both ends of the pipe.

## Melting Kettles

Melting kettles and dispensing kettles are all very similar in general construction, but vary greatly in arrangement. Stationary kettles used for melting enamel are most satisfactorily gas-fired. Thermostats provide for automatic control of the flame to produce enamel of the right temperature, without destructive overheating. In many plants these kettles are mounted on platforms or balconies so material can be run by gravity to the point of use. Plants using troughs for lining pipe run the material directly from the melting kettle to the

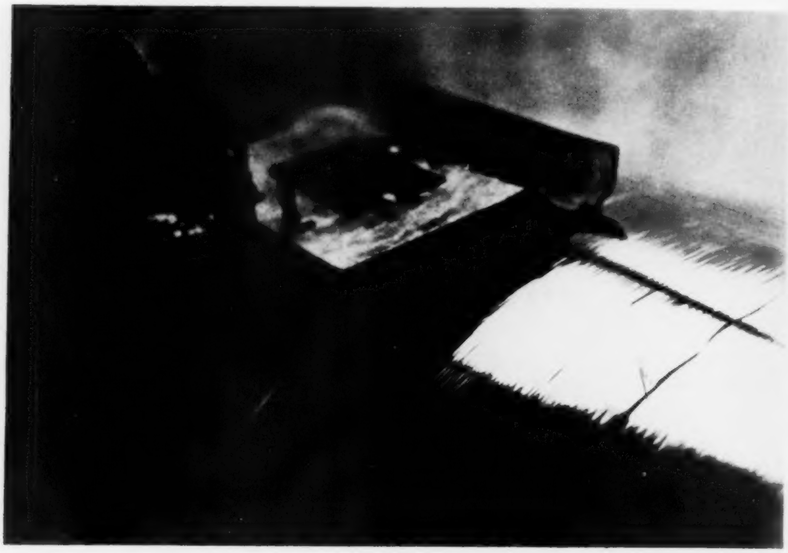

FIG. 18. Enamel Coating Spreader

trough. These kettles are in pairs and are used alternately, material melting in one while being drawn from the other. Enamel should not be drawn for use from a kettle while melting is in process, as the material would not all be of the same temperature.

Traveling kettles are filled with melted enamel and need only to maintain the proper temperature. Some of these are electrically heated and others are gas-fired.

Agitators and thermometers are necessary kettle accessories. Some power agitators are in use; but most kettles are stirred by hand every 10 to 15 min., using a steel paddle to give the bottom of the kettle a good scraping thereby raising and mixing any filler that has

settled. Thermometers of various industrial types are used, varying from well-guarded mercury thermometers to recording types that furnish a check on all batches of enamel.

The enamel, as delivered by the manufacturer in light steel drums, should be stored in a cool place. When ready for use, it is broken up with axes until small enough for charging into the kettles. If, at this time, the enamel is cold and brittle, it will break up much more readily into pieces not larger than a man's head. Breaking is hazardous work and must be done by good axe-men, equipped with foot

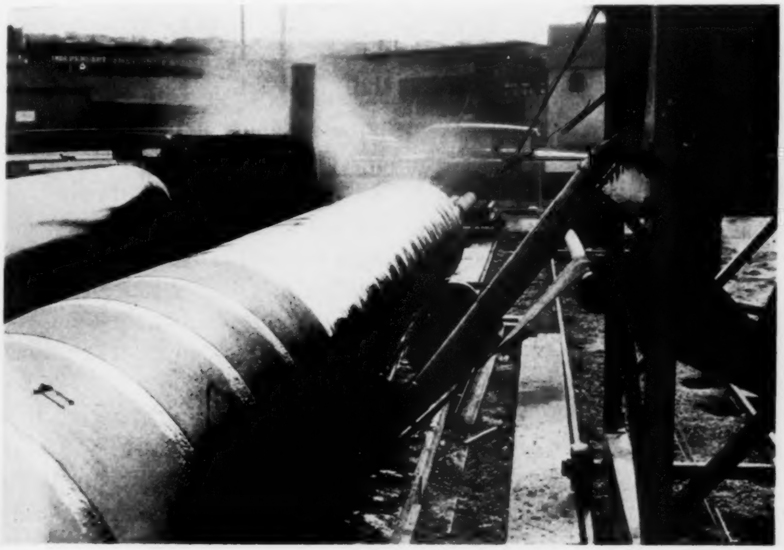

FIG. 19. Application of Bonded Wrapper with Portable Equipment

guards and goggles. The work must, of course, be done in a wire enclosure to protect other workmen from flying pieces.

It is a common practice to have a night crew break up enamel for the next day's use. This crew then charges and fires up the melting kettles early enough in the morning to have fresh enamel ready for use by the applicators.

All kettles are drained and thoroughly scraped and cleaned of all coke or settled-out filler immediately upon completion of a day's work. If a plant is in continuous 24-hour operation, every kettle must be emptied and cleaned at least once a day to eliminate defects in the coatings from lumps of enamel and filler or particles of coke.

### Enamel Troughs

The two-trough method of lining results in troughs sufficiently short so that they can be cantilevered from a car without support for the outboard end. Such a dumping trough is shown in Fig. 3, receiving its charge from a storage kettle through the small trough at the left. The quantity of enamel is measured by filling to a gage attached to the dumping trough on the edge opposite the pouring lip. In this picture, a dam that has been set for the length of pipe being processed is preventing the filling of about a foot of the length of the trough.

Single troughs as long as the pipe are shown in Figs. 4 and 9. Because such a long trough cannot be made rigid enough for pouring while supported from one end, an auxiliary support is supplied. Figure 4 shows the trough ready to pour. The small pipe running to the lower left corner of the picture has engaged a trunnion on the end of the trough. While filling, the end of the trough is supported on rollers near the end of the pipe. The trough is then advanced about half way into the pipe to be lined, being supported at its center by the roller. The auxiliary support, consisting of a heavy pipe, shown in the lower left in both Figs. 4 and 9, is introduced from the other end and engages the end of the trough. The trough can then be pushed forward, supported and kept level by this auxiliary.

A pouring trough assembly consists of a V-trough supported by a boom which is cantilevered to a counterbalanced car. The trough must have and maintain a straight and level pouring lip despite the varying temperatures and changes of position during pouring. The boom should be relied upon to prevent the bending and twisting that might permit one part to pour before another or to permit the pouring of a lining of varying thickness. The short trough in Fig. 3 and the long trough in Fig. 9 use sections of heavy pipe for a supporting boom. In Fig. 4 the supporting structure is built up of shapes into a triangular structure. Both of these constructions give a boom that is equally stiff in all directions so bending or winding will not occur while it is being rotated for pouring.

The troughs are heated by electric-resistance heaters attached to the trough under heavy insulation. This is to maintain the enamel at a proper temperature for application and to prevent a build-up of cold enamel on the trough. A hot trough is extremely easy to clean and the film of enamel left is scraped off very quickly after each pour-

ing. The strip heaters available in the past have been subject to annoying burnouts, but there has recently been offered a heater of more rugged construction and capable of continuous use at higher temperatures.

## Booms, Weirs and Nozzles

Plants using retractable weirs for applying enamel to the inside of pipe carry the spreading weir on the end of a rigid boom of sufficient length to reach the far end of the longest pipe to be lined. Figures 6, 8, 10, 11 and 12 show such equipment. The boom is mounted on a counterweighted car traveling on carefully leveled tracks. The car is equipped with an enamel kettle and a pump to force the enamel through a pipe on the boom into a weir box which is designed to spread a flow of enamel smoothly on the spinning pipe.

The boom shown in Figs. 6 and 11 is a shallow box girder with cable back stays. That shown being erected in Fig. 8 and completed in Fig. 12 is a tapering box girder. The boom in Fig. 10 accommodates pipe 50 ft. long.

In operation the weir carried on the end of the boom is passed all the way through a pipe and projects beyond the end. The pump is started forcing enamel into the weir box and spilling into a receiver as shown in Fig. 10. Hot enamel is permitted to flow to heat the weir and supply pipe thoroughly and to establish steady flow. Then, with the pipe spinning at the proper speed for centrifugal casting, the car is started, drawing the weir through the pipe. The speed of the car is such that several thin layers of enamel are applied to any spot. When the end of the pipe is reached the enamel flow is stopped, the pipe removed, and a new pipe placed.

Three methods are in use to avoid, as much as possible, the cooling of enamel in the pump, supply pipe and weir, while pipes are being changed. Electric heating with thick asbestos insulation is quite satisfactory. Gas burners inside the boom introduce a hazard of fire. When they are placed in a special furnace, heating the air to be blown through the boom, however, they give excellent results (Fig. 12).

The weir, Fig. 10, is just a box that maintains a pool of enamel flowing over a lip about a foot long. Splashing and surging are prevented by the shape. It is frequently necessary to suspend the box by a swivel joint, so it can be raised to pass over stiffening rings in the ends of large thin walled pipe.

For pipe smaller than it is possible to line with the weir, nozzles are substituted for the weir box. The large boom is eliminated by permitting a supply pipe and nozzle to be supported by the pipe being lined. Very small pipe is lined with a single pipe and nozzle. Enamel must be pumped through the supply pipe and spilled to keep the pipe and nozzle hot. Such equipment is shown in Fig. 13. Enamel spilled into a hopper for this purpose is returned to a kettle. In one plant it is pumped right back to a kettle; in others it is allowed to cool and is broken up for remelting in quantities not exceeding 10 per cent of new enamel used.

One of the newest plants, Figs. 5 and 14, uses a return pipe, continuously pumping hot enamel, thus saving time in heating-up between applications, and greatly reducing the enamel spilled and remelted. The two pipes, tied together at frequent intervals, constitute a fairly stiff structure and, with the aid of a center support, the nozzle can be kept from bearing heavily on the pipe being lined.

At the finish of a day's work all pipes, pumps, weirs, and traveling kettles must be drained as thoroughly as possible. The layout of the piping is such that there are no undrained pockets to be plugged by congealed enamel. The first step in starting work is to heat the long supply pipe. Gas burners in a trough between the tracks (Fig. 13) accomplish this, and gas burners in a portable shield are used for the pipes in Fig. 14.

## Coating Equipment

Pipe coating is frequently done on the same spinning equipment as lining. The two processes cannot be carried on simultaneously because lining requires high speed to produce high centrifugal force while coating can only be done at a speed so low that centrifugal force does not throw off the molten enamel. Figure 17 shows the same pipe as Fig. 10, with a traveling car spreading enamel on the outside. The plants illustrated in Figs. 4 and 9 also use one spinning machine. The equipment shown in Fig. 16 is separate from the lining equipment, resulting, of course, in higher production.

Equipment used for coating only is simpler than that for lining. No hold-down devices are needed and very little speed variation is required in the drive. Otherwise the spinning machine is very similar to that used for lining.

Coatings vary greatly in their make-up depending on the preference of the designer of the pipe line. They all start with a basic coat of

enamel. Some engineers have this coated with whitewash and stop there; on other jobs one or two bonded wrappings are added.

The base coating is applied by pouring a stream of enamel on the pipe surface and spreading this to a uniform thickness. The spiral lead is such that two or three layers build up the desired thickness. Enamel is poured from special buckets, by hand, in field jobs or in the coating of a very few pieces. The spreader shown in Fig. 18 is attached to the spout of a hand-pouring bucket, but is typical of the spreaders shown in Figs. 4, 16, and 17 with traveling kettle equipment. The enamel discharge pipe from the pump on the car is usually fitted with ball joints or a section of flexible metallic hose. It can be kept hot by swinging it around to discharge into the kettle between applications.

## Traveling Kettles

Traveling kettles mounted on cars are used by all plants for dispensing enamel to the various spreading devices, for both lining and coating and wrapping. Enamel is never melted in these kettles but is maintained at application temperature after being drawn from a melting kettle. The cars are operated at various speeds by different means. Where wrapping is done the car travel and pipe rotation must be synchronized, so the car is driven by chain or cable.

Where no exact synchronization is needed cars are usually self-propelled by electric motors. Variable-speed drives, under the control of an operator who rides the car, transmit the power. Separate driving motors with variable-speed transmissions are provided for operating enamel pumps.

The enamel pump is run continuously through a day once it is warmed up. There is usually a bypass returning enamel to the kettle. Positive displacement pumps are used, but there is no consensus as to the superiority of vane or gear types. Because of temperature distortions, the runners must usually be more loosely fitted than is customary practice, but the pressures to be delivered are low and pump slip is not significant.

Stationary control stations are used for operation of the cars shown in Figs. 8, 9, 11 and 13, combined with the pipe spinning control. In Figs. 4, 10, 14, 16 and 17 enamel car and pipe spinning controls are separated, a rider controlling the car and the enamel spreading. Electric cables and gas hose for the car are draped from an overhead trolley wire in Figs. 14 and 16, trail between the tracks in Fig. 17, and trail to one side in Fig. 4.

## Wrapping Equipment

Two wrapping equipments are illustrated in Figs. 7 and 19. In Fig. 7 enamel from the kettle flows by gravity to a wide nozzle and to the top of the pipe. In Fig. 19 the enamel flows by gravity to the ribbon of wrapper, which is immediately rolled against the pipe. Synchronization of starting and speeds of pipe and wrapping car is necessary. Wrapper guide rolls are usually flexibly mounted, allowing them to adjust themselves nicely to the spiral angle of the wrapper. Tension is put on the wrapper in two ways. Friction against the traveling ribbon of the wrapper can be applied by a weighted belt. Another method used with great success is to provide adjustable friction disks on the shaft of the wrapper spool. A belt can be seen in Fig. 7 bearing against the spool of wrapper on the car.

The plant shown in Fig. 19 is designed for field use and can easily be knocked down for moving. The kettle is placed high enough to deliver enamel by gravity. The use of cable for driving the car from the spinning machine gives ease of installation when moved.

## Pipe Handling Equipment

In some plants, overhead cranes are available and very little rolling of pipe is done. In others, pipe is rolled on runways from one process to the next. In the plant in which Figs. 3 and 16 were made, raw pipe is placed by crane at one end and finished pipe removed by crane at the other, all intermediate moving being by rolling on runways.

Because of an angle in the runways in the plant illustrated in Figs. 14 and 15, a special transfer hoist is installed at the angle, to swing pipe from one leg to the other. In the plants in which Figs. 1 and 4, 10 and 17, and 2 and 11 were made, overhead cranes are used for most moves. Figures 7 and 9 show a plant where pipe must be brought in endways on a car and rolled by hand.

Wherever pipe is rolled by hand, means are provided to raise the pipe from the spinning rollers and start it on its way. Figures 7 and 9 show slanting beams, the lowered ends of which are raised by air cylinders; in Figs. 1, 3, 4, and 16 similar lifting jacks are in evidence.

It is necessary to move pipe axially to adjust it to the exact position for placement on the spinning machines. This is done by placing rollers in short gaps in the runways. These rollers can be turned by ratchet wrenches to align the pipe with the end-stops on the spinning machine.

## Miscellaneous Equipment

Small amounts of smoke issue constantly from vents on all enamel kettles but this is not sufficient to be troublesome. When enamel is spread, exposing large areas of hot enamel, in coating the inside and outside of large pipe, fumes are released in clouds. As most plants are in heavy manufacturing districts no attention is paid to this, except to provide respirators for the operators.

One plant, Fig. 3, has a few residences to leeward from the prevailing wind, so the worst of the fumes are collected. Part of the suction pipe shows overhead to the right of the figure. A hood encloses the far end of the pipe and when enamel is dumped the fumes are gathered up and drawn through a spray washer which condenses most of them.

Smoke hoods on collection systems are a nuisance to the operator and are extremely difficult to adapt to various pipe sizes. Condensation from fumes on hoods, pipes, and blower runners is very hard to clean off.

Pipe having a large ratio of diameter to thickness must be provided with stiffening rings in the ends while being lined, or its flexibility will cause serious jumping and vibration and result in a poor lining job. Such rings are evident in Fig. 6.

Effort is made to place a perfect coating on pipe and to get it into the ground without a break in continuity. Taking advantage of enamel's high dielectric strength, the search for flaws is made with a wire brush charged with high voltage from a spark coil. Any pinhole or thinly covered bubble is indicated by the jumping of the spark. This test is made at all plants and is usually made in the field before backfilling.

Various devices operated by cylinders are used. Jacks for raising pipe from spinning machines, opening and closing doors of blasting rooms, raising pipe for turning, holding down pipe while spinning, are among the uses found. Whether air or water should be the power medium depends upon the requirements of the operation. Air is quick but extremely elastic and expansible. This results in poorer control of speed and can cause bouncing and slamming. Water, being incompressible, can be controlled nicely.

Runways must be level and sturdy. Both wood and steel construction are used. Wooden runways must be provided with steel rails giving very small contact with the pipe surface in sections where primed pipe is rolled, in order to reduce the area of priming that

might be damaged by contact with the runway while rolling. Wide rubber padding is advisable on runways that receive coated pipe.

The author is indebted to and hereby expresses his appreciation to the various protective coating applicators who so kindly furnished photographs of, and information on, their equipment.

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# Fittings and Specials for Steel Pipe

*By Russell E. Barnard*

IT REQUIRES more than plain pipe to make a pipe line. There must be junction pieces between valves, meters, and other fixtures, as well as joints with other kinds of pipe. Small pipe joins the same size or larger pipe in all manner of directions and under various circumstances. The particular units of equipment which must be applied to meet these different requirements, though perhaps small in number, are vital to the satisfactory operation of pipe lines. Their proper design therefore is of utmost importance. It is the purpose of this paper to give a brief non-technical picture of some of these units.

The problem of flanges, fittings and specials originated with the first pipe lines. At first, of course, each engineer used his own ideas in solving the problems as they arose. Then, gradually, individual companies developed their own standards, which might or might not correspond with those of other companies. The chaotic condition which developed with such individuality in approach, however, led eventually to the establishment of national standards sponsored by influential organizations. Among the present official national standards are those for flanges and certain of the more common fittings, such as elbows, tees and reducers.

Standards have been developed for cast-iron and for steel flanges. Steel flanges, for instance, are classified according to primary pressure and temperature ratings. The present 150- and 300-pound standards are principally for the use of water works engineers. These are refined editions of the former 125- and 250-pound American Standards.

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A paper presented on June 23, 1941, at the Toronto Convention by Russell E. Barnard, Advisory Engineer, Spiral Welded Pipe Department, American Rolling Mill Co., Middletown, Ohio.

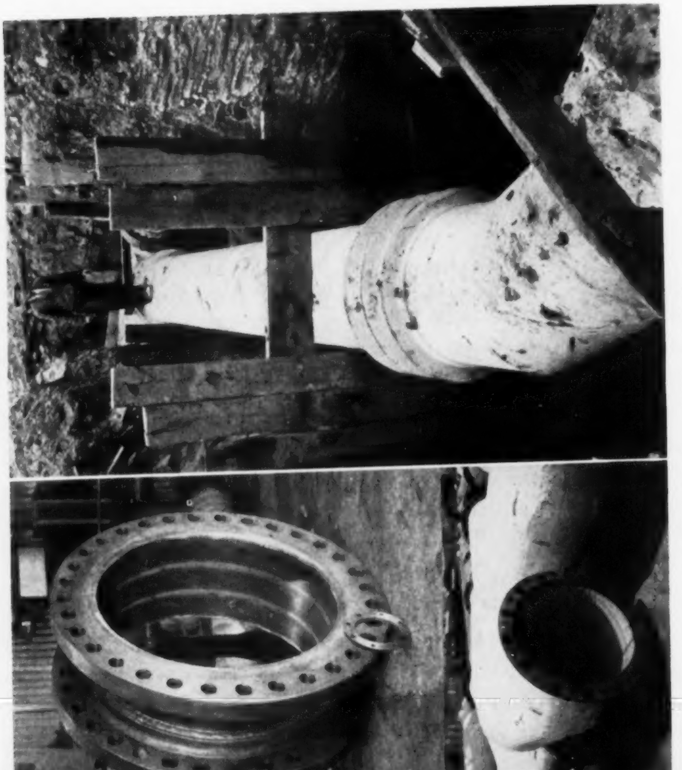

Fig. 1. Left; Fig. 2. Upper Center; Fig. 3. Lower Center; Fig. 4. Right

## Application of Standards for Flanges

The standards for steel flanges have been developed to provide for all types of high pressure and high temperature work. Some difficulty has arisen in application of these standards, however, in that some water works engineers are inclined to apply them without thorough examination of local requirements. In many cases, for instance, the 150-pound standard is considered applicable only to pressures up to 150 lb. Consequently, with a cold water working pressure of 175 or 200 lb., a 300-pound flange is specified. Actually, of course, the cold water service rating for the present 150-pound American Standard steel flange is 230 lb. per sq.in. when temperatures do not exceed 100°F., and temperatures below 100°F. usually prevail in water works service. Similarly, flanges having a primary service pressure rating of 300 lb. per sq.in. at 750° service temperature have a maximum non-shock service rating of 500 lb. per sq.in. when the service temperature is 100°F.

Failure to recognize the actual pressure ratings of flanges for cold water service results in such over-design of flanges as indicated in Figs. 1 and 2, Fig. 2 showing the extreme of flange design.

The common types of steel flanges for welding are slip-on, welding-neck and Van Stone, or lap-joint, flanges. Of these, the slip-on type is the best for water works service.

The proper design of flanges is a complicated task. Responsible manufacturers can be helpful in design; their aid should be solicited whenever situations warrant. Complete reliance on published data, which is sometimes inadequate, often results in over-design of flanges for cold water service.

## Standard Fittings

Dimensions of certain fittings have been standardized by the American Society of Mechanical Engineers and have been adopted nationally. For the most part dimensions refer to 45- and 90-degree elbows and to tees, crosses, 45-degree laterals, and reducers, both concentric and eccentric. Each standard fitting is a separate unit, complete in itself.

Again with the standard fittings as with the standard flanges, the primary service pressure ratings are rather higher than encountered in ordinary water works practice. Due consideration should be given to this fact by the designers using them.

## Specials

One of the principal advantages of steel pipe is its adaptability under almost any condition. Full advantage may be taken of this adaptability by proper design. Savings in material and installation costs are to be obtained by good engineering practice. Figure 3,

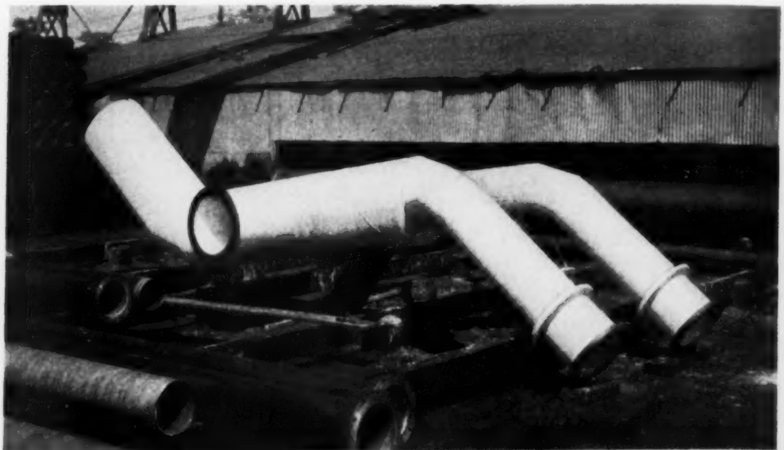

FIG. 5. Top; FIG. 6. Lower Left; FIG. 7. Lower Right

for instance, illustrates the simplest of cases—an elbow with one leg longer than the other, which eliminates a filler piece. In Fig. 4, on the other hand, an elbow is combined with a set of anchor rings and a special calking spigot. Far more complicated, too, is the combination fitting in Fig. 5. Custom-built to fit the conditions, this special eliminates many joints which are costly and difficult to assemble.

*Tees and Crosses*

Tees are common fittings in almost any pipe line. When pipe wall thicknesses are suitable, threaded taps for small outlets of threaded pipe may be made direct in the pipe wall or, optionally, by means of factory-welded "Thred-o-lets" (Fig. 6) or half couplings. Larger steel pipes may be joined by means of flanged tees as shown in Fig. 7, or by smooth barrel stubs for Dresser couplings.

The scheme of bell connection for cast-iron pipe shown in Fig. 8 is not recommended. A better method is to provide the steel pipe

FIG. 8

FIG. 9

FIG. 10

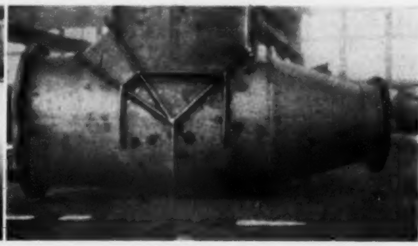

FIG. 11

with a proper length steel outlet pipe carrying a calking spigot. The spigot may have an end bead, as shown in Fig. 9, or be smooth as in Fig. 10.

Large diameter tees are reinforced when necessary as shown in Figs. 11 and 12. Welded steel pipe crosses may be plain or with throats as shown in Fig. 13.

*Reducers*

Reducers are more frequently than not combined with straight pipe sections or with other fittings as in Fig. 11.


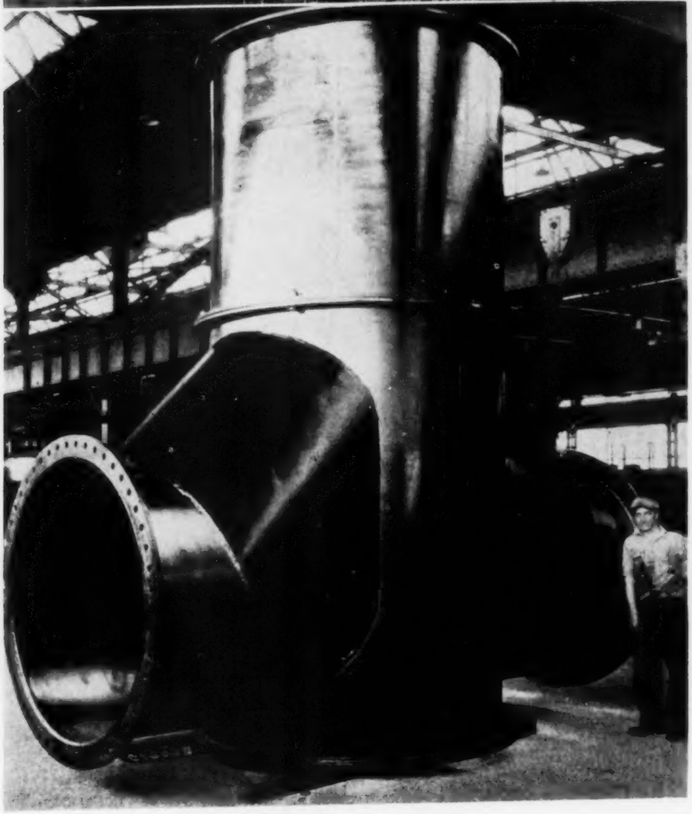

Fig. 12. Top; Fig. 13. Bottom

*Wyes and Laterals*

Wyes and laterals of steel are not especially difficult to fabricate. Care must be taken that reinforcement is provided if necessary. Reinforcement as shown in Figs. 1 and 14 is satisfactory, but patches such as in Fig. 15 have no place in modern welding practice. The

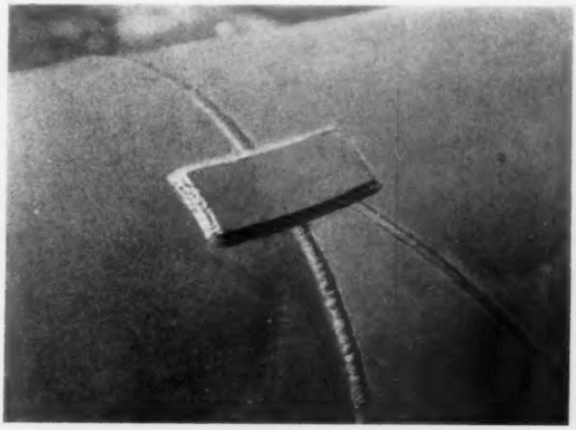

FIG. 14

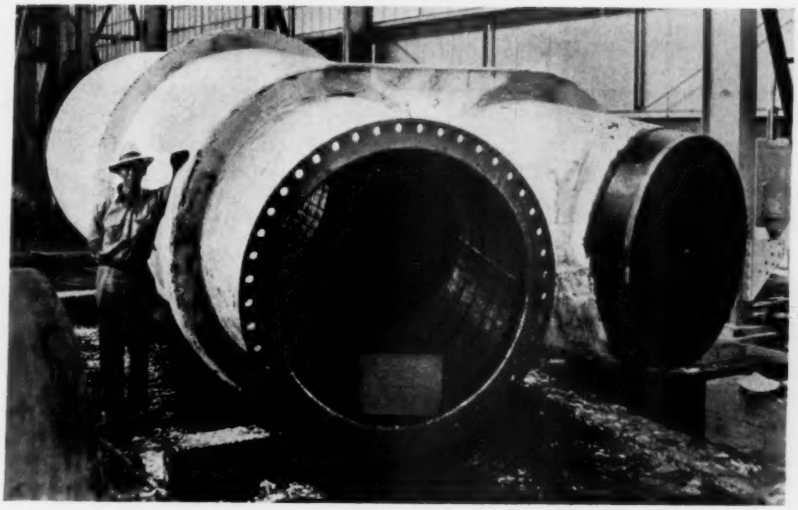

FIG. 15

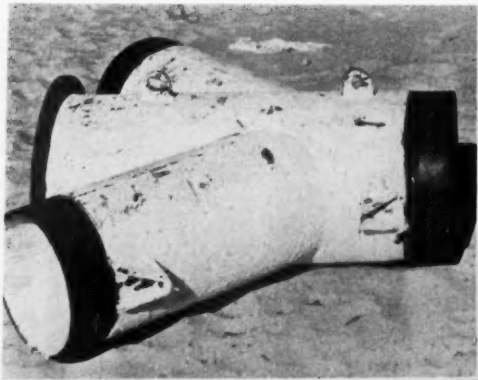

Fig. 16. Upper Left; Fig. 17. Upper Right; Fig. 18. Bottom

Fig. 19

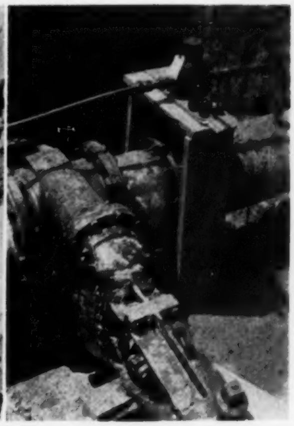

Fig. 20

special wye shown in Fig. 16 is not reinforced but contains an interesting assortment of lifting lugs and lugs for harness joints. A Dresser joint harness is shown in Fig. 17.

The lateral in Fig. 18 is not only reinforced but contains in one piece a welded-in head, a threaded outlet, a calking spigot for joining to cast-iron pipe and an anchor ring.

*Valve Connections*

Valve connections are commonly made by calking as in Fig. 19, or by flanging as in Fig. 20. Some valve companies now furnish valves with stub ends for use with Dresser couplings. A valve is relieved of line stress if a Dresser coupling is used near it, as shown in Fig. 20.

FIG. 21

*Expansion Joints*

Expansion joints of the packing-ring type are available for use with steel pipe. A pipe line crossing a bridge should be provided with expansion joints at the expansion ends of trusses or girder spans. Expansion joints may be placed in other lines at such points as might be seriously affected by stresses due to temperature change.

*Blind Ends*

A run of steel pipe may be closed by means of the standard bolted blind flange, a welded-in reinforced head, or by Dresser line caps as shown in Fig. 21. A dished head welded to pipe end in convex or concave position may also be used. It is preferable that the dished

head be attached so that it is concave to the pressure, since greater strength is thereby obtained.

*Manholes*

The entrance to a manhole may be provided with a standard flanged tee connection and blind flange or with a yoke-type frame and cover, as shown in Fig. 22.

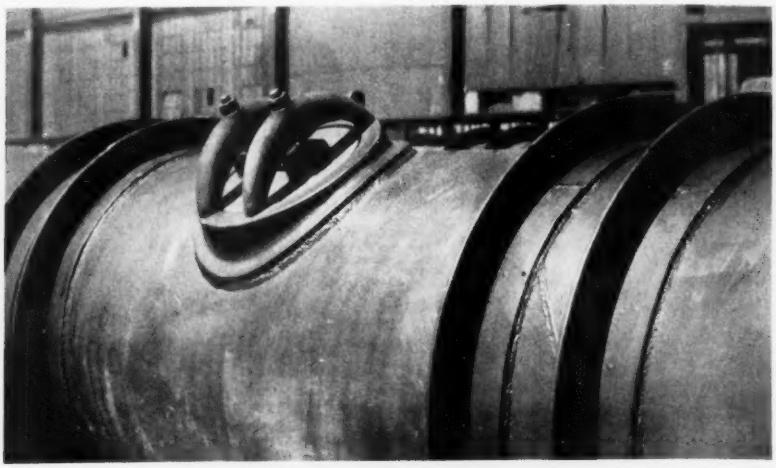

Fig. 22

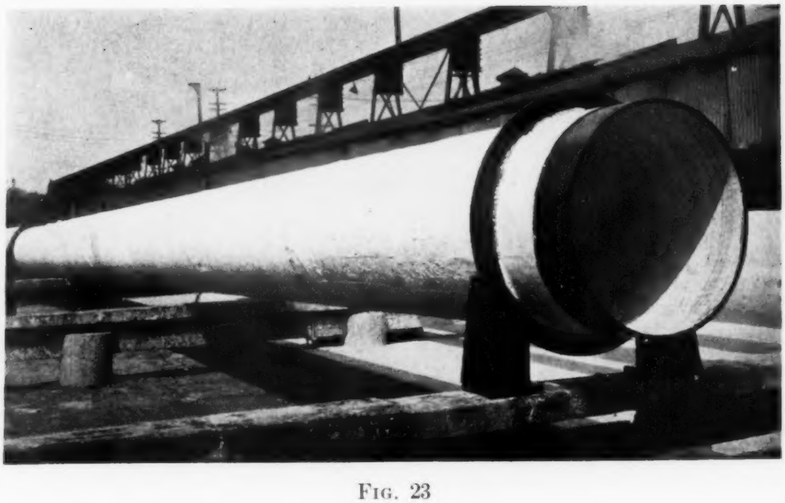

Fig. 23

*Pipe Bridge*

By means of the ring-type support shown in Fig. 23, steel pipe may be made self-supporting over long spans. The ring and pedestals are designed to take full advantage of the great inherent strength of steel pipe.

## Hydrostatic Testing of Fittings

Many fittings are of such shape that, when tested hydrostatically, large unbalanced forces are caused. After a fitting has been installed in the pipe line, these forces are counteracted by blocking and tying.

TABLE 1

*Pipe schedule for an equalizing force main*

| STATION | UNITS AT AND BETWEEN STATIONS |
|---|---|
| 3 + 50.75 | Begin contract |
| | Vault No. 1 |
| 3 + 40 | Cross mark 3 + 40 |
| | Expansion joint } Same for North and South lines |
| | 11 pcs. @ 40′ |
| | 1 pc. @ 30′ |
| | Expansion joint |
| −1 + 34 | Ell mark − 1 + 34 |
| −1 + 37 | Ell mark −1 + 37 |
| Equation Sta. −1 + 37 = Sta. 15 + 46.83 | |
| West Pipe | |
| 15 + 46.83 | Ell mark 1 + 37 |
| | 9 pcs. @ 40′ |
| 19 + 08 | Expansion joint |

By itself, however, a fitting does not possess these necessary supports and, unless unusual plant testing facilities are available, or the fitting is designed for testing instead of service, its testing to any pressure greatly in excess of working pressure is more apt to be harmful than beneficial. Engineers should limit testing pressures on fittings to low intensity to prevent undue distortion.

## General Design

The engineer who is planning to take full advantage of available equipment, should draw his specifications on specials so that the

manufacturer will be permitted to offer his most economical design to meet the conditions imposed.

The layout work for steel pipe lines need not be complicated. The serial numbering of interchangeable pieces should be avoided and a single identifying mark adopted. In many cases a simple list acting as a material laying schedule can supplant voluminous drawings. The material list, or pipe laying schedule, method (Table 1) is simple and its advantages should not be overlooked. The pipe schedule is equally useful to the project engineer, the pipe line designer, the pipe manufacturer, the shipping clerk, the receiving clerk, the drivers on distribution trucks and the pipe laying superintendent. In many cases the pipe schedule obviates the necessity of any but the original survey drawings.

# Cleaning and Lining With Bitumastic Enamel

***By J. M. Kamps***

THREE methods of restoring the carrying capacity of water mains are available: (1) building a new main; (2) cleaning the mains and introducing chemical treatment; and (3) cleaning the mains and applying a protective coating to maintain the restored carrying capacity and to prevent any further structural deterioration of the pipe. It is with this last method that the author shall be concerned in this paper.

The methods to be pursued in cleaning and coating the inside of water pipe vary to a great extent, mainly with the size of the pipe. This, in turn, more or less automatically, means that different methods are used for transmission mains (large diameter pipe) and distribution mains (small diameter pipe). Only the practice of cleaning and coating distribution pipe, for the most part bell and spigot cast-iron pipe which is usually too small for men to enter for the purpose of performing the work in place, will be covered in this discussion. The cleaning and lining of the inside of such cast-iron distribution pipe with spun Bitumastic Enamel* is now being carried out by the following procedure:

The pipe is removed from the streets and taken into the owners' distribution yard. This yard is arranged with two lines of level skids—either wooden timbers or old steel rails, spaced at a proper distance to support the varying lengths of the individual sections of pipe. These skids are long enough to provide space at one end for the cleaning of the pipe. Additional space for the application of priming solution and for the storage of the pipe while the priming solution is

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A paper presented on August 7, 1941, at the Western Pennsylvania Section Meeting, Erie, Pa., by J. M. Kamps, District Manager, Wailes Dove-Hermiston Corp., Cleveland, Ohio.

* Bitumastic Enamel is the trade name of a coal-tar enamel product of the Wailes Dove-Hermiston Corporation of Westfield, N. J.

drying is also provided. The length of the skids depends on the diameter of the pipe to be treated, and upon the amount of reconditioned pipe per day that is to be produced.

At the end of the skids is placed the lining machine, which must be installed so the pipe sections placed in it will be level. This machine is rather simple. It consists of two frames, each carrying two rollers to support the pipe at the ends. One set of rollers is power-driven; the other is an idler which is moved to accommodate the different lengths of pipe. The easiest arrangement for a power drive is to jack up the rear wheels of an automobile; equip one wheel with a pulley, 10 in. in diameter and having a 5-inch face. Such

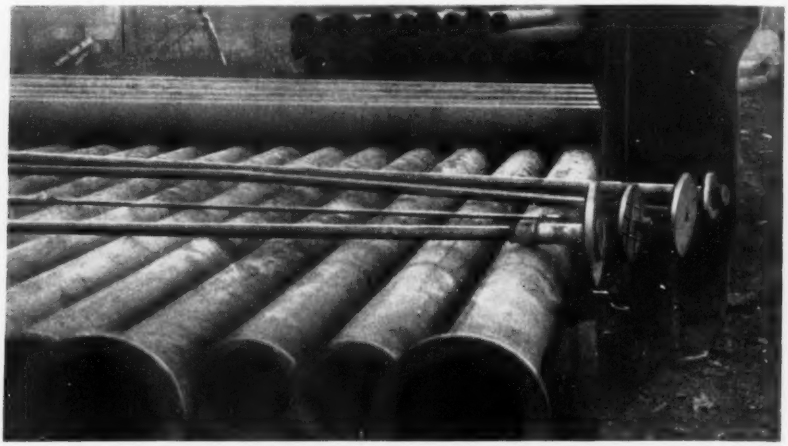

FIG. 1. Disc Cleaning Tools

a pulley can be secured from many sources, including the mail order houses. A belt is then stretched from this pulley to a pulley on the driving end of the spinning rig. This type of drive, while it may seem crude, is really very effective, and, of course, very economical.

Beyond the coating machine is arranged a similar set of skids upon which to place the pipe, after its removal from the lining machine, first for whitewashing the outside and then for storage.

## Removing Incrustation

The cleaning of the inside of the pipe is usually performed by steel discs on long rods (Fig. 1). The diameters of the discs vary not only with the nominal diameter of the pipe, but also with the amount of in-

crustation. If the pipe is badly incrusted, a small diameter disc is run through first, followed by other discs of increasing diameters. The work is best performed when the incrustation is damp, as it is then more easily removed. Consequently, if the incrustation has had an opportunity to dry subsequent to its removal from the line, it is good practice to wet it by spraying the interior with a hose before starting the cleaning operation.

The final cleaning is accomplished by wire brushes. In the case of badly pitted pipe, however, hand scrapers are used. These can be made readily from old automobile spring leaves. To reach the center of the pipe, the springs may have to be mounted on suitable rods. Sometimes the cleaning is finished by revolving the pipe with a weighted wire brush pushed through it. The cleaning must, of course, be thorough, and as much of the old incrustation and rust as possible removed.

### Application of Primer

After the pipe is cleaned, and while the surfaces are dry, the inside is given one coat of priming solution applied with good quality bristle brushes mounted on rods. The solution should be well brushed out, and great care taken that all surfaces are covered. No runs, festoons or accumulations of heavy primer should be permitted. The covering capacity varies with the roughness of the surfaces, but, generally speaking, it should be about 350 to 500 sq.ft. per gallon of primer.

The primer dries by the evaporation of the volatile solvent. In warm weather, it dries quickly, provided there is a sufficient natural circulation of air. On the larger diameter pipe this is no particular problem, but on small diameter pipe—from about 4 to 8 in. in diameter—the drying will be slower unless some sort of ventilation, such as placing the pipe in the direction of the wind, can be provided. Before any lining is attempted, the interior of the pipe should be examined to make sure that the primer is *absolutely dry*.

### Placing the Enamel

In lining, the pipe is rolled into the lining machine, and "dams," which are merely holed discs of thin sheet steel, are fastened on the spigot end by clips, and inserted in the bell end. The proper amount of hot enamel is then introduced at each end of the pipe by inserting the spout of a special pouring can through the center openings of the ring dams (Fig. 2). As soon as this has flowed to the center of the pipe,

the power is applied to the driving end of the rig. This starts the pipe spinning and distributes the hot enamel over the entire inside surfaces, providing sufficient centrifugal force to hold it in place until it

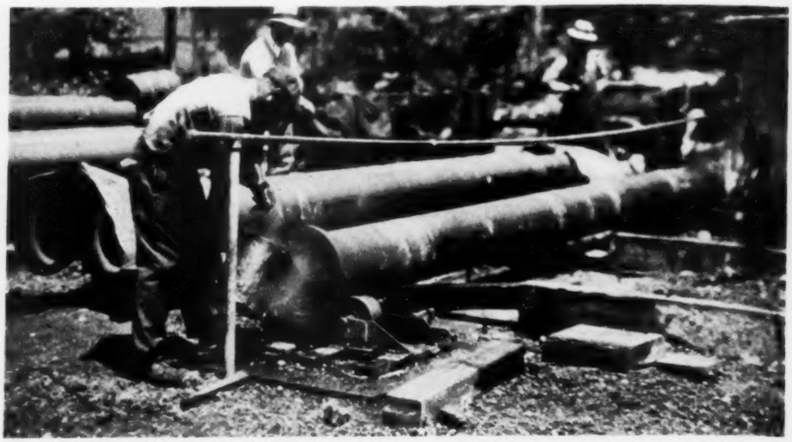

FIG. 2. Pouring Hot Enamel into the Pipe End prior to Spinning

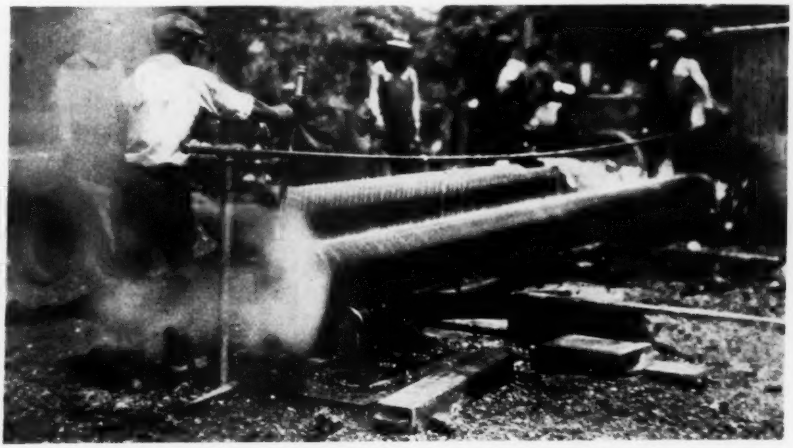

FIG. 3. Cooling Spun Lining with Water Spray on Outside of Revolving Pipe

"sets." Setting occurs very quickly, as it is due entirely to extraction of heat from the coating by the metal of the pipe. In many cases the cooling effect is accelerated by applying water to the outside of the pipe (Fig. 3).

As soon as the enamel has set, a matter of only a few minutes, the power is cut off, the ring dams removed, and the pipe removed from the machine on to the delivery skids. The ring dams are prevented from sticking to the enamel by a coat of very light grease applied before installation. Finally, the pipe is whitewashed on the outside and stored, ready for installation at some other location in the system.

The method is very simple, and produces a smooth internal lining with a minimum thickness of about $\frac{3}{32}$ in. Flow tests have indicated that the Williams-Hazen coefficient of the re-lined pipe, based on nominal diameter, has been as high as 158. It is safe to assume a coefficient of 150, or to be very conservative, not less than 140, and to guarantee a much greater carrying capacity than the pipe had before it was lined.

One of the main advantages of this method is that it is now possible to remove badly tuberculated pipe from the distribution system to the repair yard and replace it with pipe of the proper diameter, thus restoring, immediately, the carrying capacity of the section of town from which the pipe was removed. The carrying capacity of the tuberculated pipe can then be restored by the method described and the pipe laid in a new location with the full assurance that, with its restored capacity, it will give many years of useful service.

# Development of Houston's Water Supply

*By G. L. Fugate*

SOME knowledge of the history of Houston as a city is necessary to the understanding of its water supply problem. Thirty-five years ago when the city purchased the water system, the population was less than 50,000, centered around the upper limits of tidewater in Buffalo Bayou, a tributary of the San Jacinto River. According to the 1940 Census, present population is 386,150, representing an increase of more than 650 per cent.

A key to this phenomenal growth is the ship channel which was completed in 1915. For years previous to that date, the possibility of constructing a channel, large enough for ocean vessels, to connect the city with the Gulf of Mexico, 50 miles away, had been argued, and finally, with success, for in August of that year the first ocean vessel dropped anchor in the Port of Houston.

Hardly had the ship anchored when a West Indies hurricane, the worst on record at the time, crossed the Gulf coast line into Texas, the center passing within a few miles of Houston. Vessels at anchor in the nearby Gulf harbors were battered, some of them sunk, others blown inland on the tidal wave, but the one in the new Port of Houston rode the storm safely.

These events proved two things: (1) that Houston had become a port which could accommodate world-wide shipping; and (2) that it was a port safe from the hurricane disturbances which occur in the Gulf Coast area many times a year. The population of the city and its commerce and industry have grown without pause since that time, so that Houston is now the second largest city in the South and an important commercial and industrial center.

Many of the large industries are located on the banks of the channel for a distance of several miles below the public docks. Some of them

A paper presented on June 26, 1941, at the Toronto Convention by G. L. Fugate, Chief Engineer, Water Department, Houston, Tex.

use water at rates of from 5 to 20 m.g.d. to process their products. The metropolitan district, on the other hand, demands 78 m.g.d., with an additional fringe demand of 3 m.g.d. In an area of 825 sq.mi., including water used for rice irrigation, the total exceeds 140 m.g.d. (Fig. 1). This entire demand is taken from the ground water resources. Houston is the largest city in the Western Hemisphere depending solely on ground water as a source of supply.

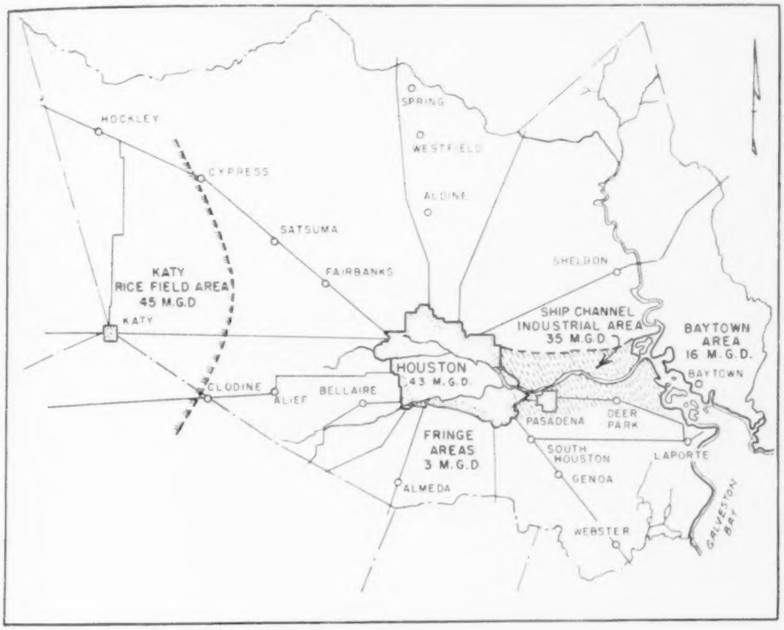


FIG. 1. Water Demand by Principal Areas of Houston, 1940

## Geology of Ground Water Supply

This vast withdrawal, confined within a relatively small area, lends importance to the geology of the supply. Broadly generalized, the district lies within the west Gulf Coastal Plain. A series of escarpments, believed to represent ancient shore lines, extend across the district parallel to the present coast line, the most pronounced being about 80 mi. from the coast. The topography south of this escarpment is a plain sloping upwards from the Gulf at a rate of between 2 and 5 ft. per mi., and the area north and northwest is gently rolling with a rise of about 8 ft. per mi. The underlying formations at

Houston consist of beds of relatively impervious clay, shale and gumbo, and permeable water bearing sands. These formations were deposited during several cycles of marine and continental deposition, and consist of zones predominantly clay, alternating with zones predominantly sand. The direction of their dip is normal to the coast line. They outcrop inland from the Gulf and are subject to recharge by the rainfall which averages 44 in. annually (Fig. 2).

At a depth of less than 2,000 ft. there is a total of about 600 ft. of water bearing sands containing fresh water for at least several miles down the dip from Houston. The sands, 2,100 feet below the surface at Houston, contain salt water.

As late as the year 1910 the artesian pressure at Houston was sufficient to raise the water from 30 to 50 ft. above sea level. Decline

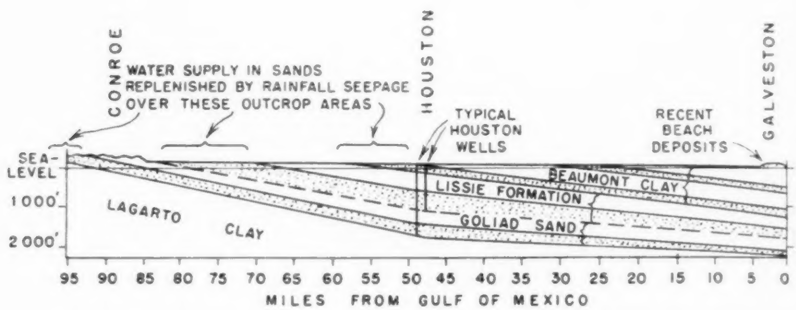


FIG. 2. Generalized Geological Section, from Conroe southeastward through Houston and Galveston

in artesian pressure began about that time and for a number of years the average rate was 5 ft. per annum. During the years of economic depression, beginning in 1930, the quantity of water withdrawn was reduced about 10 per cent and the levels rose slightly. The industrial pumping along the channel began to increase during the year 1936 and the decline in static level since that time has been rapid (Fig. 3); the lowest point now in the cone of depression is 80 to 90 ft. below sea level.

## Numerous Reports on Supply Resources

Many citizens became alarmed during the early years of decline in static levels, and believed the supply was approaching a critical stage. Other deficiencies likewise existed in the system because

the Water Department revenue was for many years placed in the City's general fund. The amount budgeted back to the Department was insufficient for proper operation and expansion to meet the rapidly increasing demands. The smaller volume of water sold without expansion would not permit the reduction of rates to meet compe-

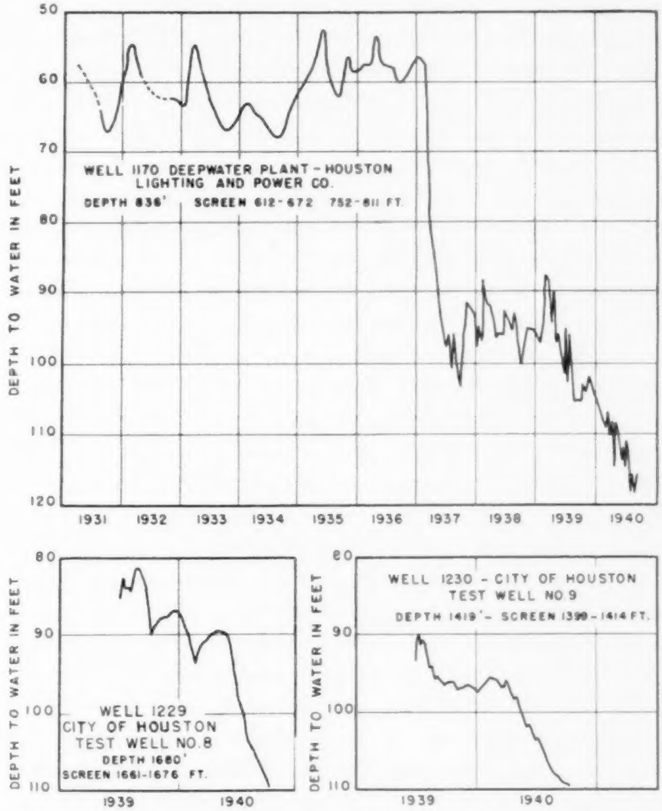


FIG. 3. Fluctuations of Water Levels in Wells in Pasadena Area

tition from private wells. The existing high static levels, together with the lack of a wholesale rate, caused many owners of commercial buildings and industries to drill wells on their building sites, and produce water at less cost than could be furnished by the public supply. The result is that the public supply now furnishes less than 40 per cent of the total metropolitan demand.

More than 40 reports on existing conditions, with recommendations for remedies, have been submitted during the past few years. These reports, although valuable, in many cases express opposite conclusions. Any attempt to evaluate them now should consider that if existing data had been available then, the conclusions might have been different.

The later reports submitted by the National Board of Fire Underwriters in August, 1937 (1); Alvord, Burdick & Howson, (2) (3), in February, 1938; and the Mayor's Advisory Board (4) during the year 1938, are important ones, covering a great deal of detail. Finally, a committee appointed from the members of the Houston Engineers Club (5) submitted a report in August, 1940, and the Texas State Board of Water Engineers and the United States Geological Survey (6) submitted a progress report on their studies of the ground source of supply in November, 1940.

Reviewing these reports briefly, The National Board of Fire Underwriters concluded that by proper spreading of well fields the ground source of supply would be ample for domestic, commercial and light industrial purposes for some time to come, but that there existed a very definite problem in regard to the industrial needs in the channel area and that this area was over-developed as regards the well supply, so that an industrial surface water source of supply appeared imperative.

Alvord, Burdick & Howson compiled much information on the existing system and pointed out many of the deficiencies. They compared, by estimates of cost, five different sources of supply and a combination of two sources. The combination involved taking water from the ground source for domestic and commercial purposes, and from the San Jacinto River as the channel industrial supply. According to their estimates, a single source of supply from the San Jacinto appeared slightly lower in cost and they favored this scheme.

The Mayor's Advisory Board was in general agreement with the National Board of Fire Underwriters. It expressed the belief that the development of an industrial supply could be postponed, and recommended the development of a new well field west of Houston.

The Engineers Club report dealt chiefly with organizing Harris County into a water improvement district to take over all public water supply in the County. It found no evidence to indicate the necessity for immediately supplementing the underground supply to meet present needs. It expressed the belief however, that the future industrial demand might require supplementary sources.

When available funds have permitted, an investigation of the ground water supply in the Houston District has been under way since December, 1930, as a co-operative project of the United States Geological Society and the State Board of Water Engineers. The latest phase of the investigation was begun in the Fall of 1938 when the City matched Federal Funds. The work has been carried on intensively since that date and many observed data have been compiled. These have made possible the use of the Theis (7) equation in a mathematical approach to compute the water level fluctuations (Fig. 3) and to compare cost resulting from various assumed pumping conditions. The static level is an important factor in the economies of producing water from the ground supply. Each foot it is lowered costs, in Houston, an additional $10 per annum for each million gallons daily pumped. The City put down thirteen test wells in unexplored sections. Some are maintained as observation wells to note fluctuations in static levels and for warning signals of salt water intrusion. The progress report submitted last year summarized the work. Since this report is based on more known data, pertaining to ground water in this district, than any other, it is given much weight. Some of its important points are:

1. The daily pumping rate for the district has increased 65 per cent since the year 1935.

2. If pumping is continued at the present rate of 81 m.g.d. for the Houston District, the artesian head will continue to decline for some years, but at a diminishing rate.

3. Any increase over the present rate of pumping will cause a further decline in water levels and a further depletion of storage in the ground water reservoir, as well as:

   a. A more rapid rate of withdrawal than the recharge on the outcrop areas.

   b. Intrusion of salt water.

   c. Reaching the point of depth from which the cost of pumping water from the wells will be excessive.

4. If it is desired to maintain the water levels at or near their present altitudes, the present rate of pumping should be reduced and a supplementary supply developed.

5. A supply of water exists north of Houston in deep sands that are practically untouched by existing wells. The extent and quality of water in these sands within economical transmission distance from the City are unknown and further exploration of this area is recommended.

The possibility of salt water intrusion has been studied insofar as existing information permits. Here the Theis equation again proved valuable to express the total time taken by a given element of water, at an original distance away, to migrate up the dip to the low point in the cone of depression. It gave values sufficiently large to indicate that this danger may not be as great as first feared. It is possible, however, that filaments of salt water might travel much more rapidly than would be indicated by the average velocity of the water. Such a condition will indicate an increase in chlorides as a danger signal long before the tolerance point is reached.

The concept that clay, shale and gumbo beds are materials of low permeability rather than impermeable, should be emphasized. Whenever hydraulic gradients exist in these structures, movements of water may take place. The lowering of the water levels, and consequent reduction of weight in the lower strata, creates such a condition and may result eventually in vertical intrusion of salt water; intrusion may, in fact, occur more quickly by this route than by advancing up the dip.

The Water Department's staff of engineers has been engaged for several years in making an independent study. Before any of the reports, above discussed, were made, the staff had concluded that the need for augmenting the ground source of supply by a surface supply was definite. On the staff's recommendation, in May, 1937, the City filed an application with the State Board of Water Engineers to appropriate the use of the San Jacinto River water. The formal permit was granted recently.

The San Jacinto River is the nearest source of surface supply. It has a drainage area, above the ship channel, of 2,840 sq. mi. and an average annual run-off of 1,000,000 acre-ft. A reservoir site is available within a distance of 15 mi. from the ship channel industrial area. An open canal is suitable for transmission for two-thirds of the distance. The water in its natural flow conforms more closely to the characteristics of the underground water than any other of the four streams investigated. The unregulated flow by diversion will provide 50 m.g.d. or more for over 75 per cent of the time. Private parties have already constructed a tube of this capacity under the channel and this is subject to lease. The reservoir site will impound from 130,000 to 150,000 acre-ft. when the main dam is constructed. Thus, by these means, an initial flow of almost 50 m.g.d., and an ultimate flow of 100 m.g.d., may be provided.

It is of interest to note that last year a 38-inch rainfall in a period of

six days, centered in southern Louisiana, within 100 mi. of the San Jacinto River. A similar storm centered over its watershed would produce a rate of run-off of not less than 450,000 sec.-ft.

## Conclusions From Reports

From the staff investigation the following conclusions were drawn:

1. It seems evident that one agency controlling the supply can best conserve water, and can furnish it at less cost, under the existing

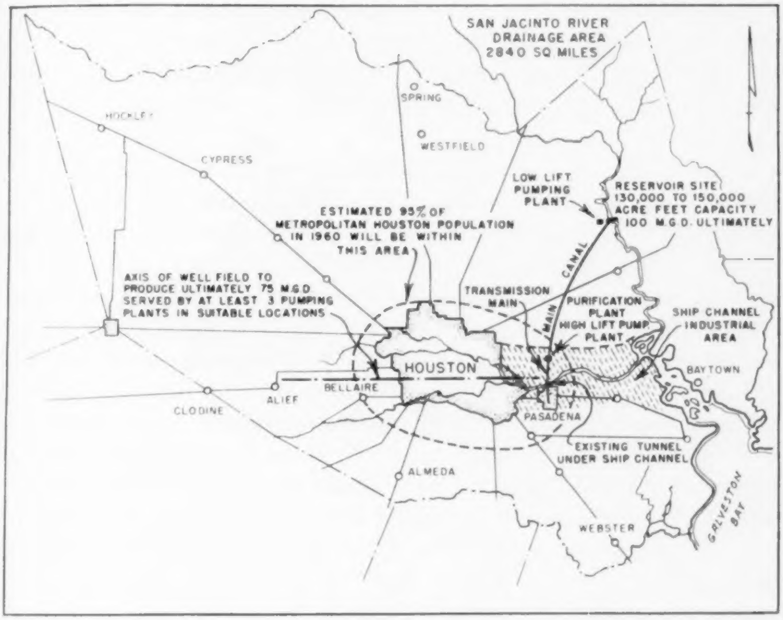


FIG. 4. Locations of Proposed Ground and Surface Supplies

static level in the Houston Metropolitan Area, than a number of individual supplies. The City of Houston is believed to be the best agency to do this. The ratio between the bonded debt of the system and the system's value is relatively low. This situation creates a nucleus around which the financing of an expansion program will be made easier and at less cost than by any other agency. Houston should prepare immediately, by adopting an adequate expansion program toward increasing supply and distribution, to serve the metropolitan area and its fringe growth in their entire demands for water at the lowest rates possible.

2. In the light of national defense alone, it is believed that dual supplies consisting of ground water and San Jacinto River water are justified even though the cost may be slightly more than for a single supply. When more accurate estimates are prepared from field surveys, the additional cost of dual supplies over a single supply, as estimated previously, may vanish.

3. The population of Houston may reach a million in 20 or 30 years. This population and the industries will require 175 m.g.d., of which 60 to 75 m.g.d. will be required in the channel industrial area. It is believed now that 75 m.g.d. can be produced safely and economically from the ground source, if well fields are grouped to the best advantage. The impounding of between 130,000 and 150,000 acre-ft. in the San Jacinto River will provide the additional 100 m.g.d. required.

4. Units to provide 50 m.g.d. by diversion from the San Jacinto River should be constructed immediately. The existing wells owned by the industries in the channel area should be brought into the public system and held in reserve to use when the flow of the San Jacinto is less than 50 m.g.d. This combination will greatly reduce the annual pumpage from the wells and will permit the static levels to rise; and the present investment in the wells will be utilized to some extent.

5. As viewed at this time there appear to be no unusual engineering problems involved in constructing dual supplies. Deep well construction in the Coastal Plain is standardized to a high and efficient degree. Conventional types of dams, transmission lines and canals may be used; but spillway capacity for the dam must be comparatively large because of the heavy rainfall along the Gulf Coastal Plain. The estimated cost of the first units of work considered necessary is about $7,000,000.

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**Discussion by *Louis R. Howson*.*** Mr. Fugate has presented a very concise picture of the history and problems confronting the Houston Water Department. Any city such as Houston which experienced a growth of almost 200 per cent in the last 20 years, adding nearly 100,000 people during the decade of the depression, might normally be expected to have experienced "growing pains" in its municipal water supply, particularly when that supply is derived solely from underground sources and in competition with industries tapping the same sources.

During this period of rapid population growth, there has not been a corresponding expansion in the City's water supply. While the population growth in the last decade was 31 per cent the City's pumpage increased but $12\frac{1}{2}$ per cent. The city now pumps only 35 per cent of the water used in the Houston-Pasadena area. The pumpage and gross revenues of the Houston Water Works are but one-half to two-thirds those of the average city of its size. This has limited its ability to finance major improvements. The total investment in the City's water works is less than $25 per capita or less than half the national average.

Some of the delay in adopting a broad development policy may be attributed to long drawn out controversy regarding surface as against underground supplies. Apparently time and increased draft from underground sources are demonstrating the necessity of developing surface sources at least for the enlargement of the supply.

Mr. Fugate has admirably condensed the most important points in the 1940 Progress Report of the U. S. Geological Survey. The following statements may, however, still further illustrate the gravity of the Houston water supply situation:

1. "During the decade from 1920 to 1930, with an average pumpage from underground sources in the Houston area of 35 to 40 m.g.d., the water level dropped about 4 ft. per year.

2. "The pumpage at the end of the decade was about 50 m.g.d. and continued at approximately that rate until 1937. During this period the water level remained substantially constant.

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* Alvord, Burdick & Howson, Engineers, Chicago, Ill.

3. "Beginning in 1937 the total withdrawal of underground water was increased to about 70 m.g.d. averaging 74 m.g.d. for the next three years and being 81 m.g.d. in 1941. During this three-year period the water level in the Houston and Pasadena area dropped an average of approximately 30 ft., or nearly *10 ft.* per year."

As Mr. Fugate points out, the population of Houston may well reach a million people in the next 20 to 30 years and when that occurs, consumption will probably approximate 175 m.g.d. In view of the relation between increased draft and recession of water levels, Houston's concern relative to its future source of supply may easily be understood.

Although at the present time, the city furnishes only about 35 per cent of the total water used in the area, this percentage will undoubtedly increase with further lowering of the water levels, which tends to make competing individual developments more costly.

I am in complete accord with Mr. Fugate's conclusion that the City of Houston should be the agency for supplying water to the entire metropolitan area and that the City "should prepare immediately, by adopting an adequate expansion program toward increasing supply and distribution." Unless the City goes into the water works business, selling to industry and securing its revenue, it cannot finance from revenues even the improvements required for adequate domestic service. Houston can no more afford to furnish only one-third of the water used in the area than can a railroad or other public utility afford to provide only a small part of the service required of it. It is believed that a central agency such as the City can develop a supply adequate for all purposes at costs less than those incurred under the present individual developments. Only by such coordination can future adequacy be assured.

The operation of a dual supply, while not in itself the most economical, offers certain other advantages. It should be acceptable to the proponents of both surface supply and well supply. The continuation of the underground supply in conjunction with the surface supply, for the present, obviates the immediate necessity of the costly storage project on the San Jacinto River, although it must be recognized that in municipal undertakings serving rapidly growing communities such as Houston, ten years in the future is, in reality, the present. To defer the construction which will guarantee the adequacy of supply under future conditions may result in shortage before a future deficiency is remedied.

# Symposium on Equipment Available for Emergency Repairs to Distribution Systems

*By Nelson Thompson, Clinton Inglee, Rossiter S. Scott and H. Y. Carson*

## Portable Pumping and Power Equipment

*By Nelson Thompson*

MANY items of equipment essential for the repair of distribution systems in emergencies are equally valuable and necessary for normal maintenance operations. Under emergency conditions such as those created by damage from major natural catastrophes, such as earthquakes, or those which result from aerial bombardment in time of war, where repair operations are demanded suddenly in many places at the same time, however, more units of such equipment than are needed for normal operations must be available. Only by having available adequate power-driven equipment can the effectiveness of the available man power be extended to cover such emergency conditions.

With the expansion of distribution systems in recent years, the equipment for maintenance has not been increased in proportion, so that many departments are not even properly equipped for normal operation, let alone emergencies. In considering power equipment which may be used to supplement man power, and speed up operations under abnormal emergency conditions, new applications are found for familiar equipment now in use, and also certain specific characteristics of a piece of equipment become increasingly important.

A symposium presented on June 23, 1941, at the Toronto Convention by Nelson Thompson, Sales Manager, Homelite Corp., Port Chester, N. Y.; Clinton Inglee, President, National Water Main Cleaning Co., New York City; Rossiter S. Scott, Consulting Engineer, Dresser Manufacturing Co., Bradford, Pa., and H. Y. Carson, President, Carson-Cadillac Corp., Birmingham, Ala.

## Important Design Factors

To illustrate how certain characteristics of a piece of power equipment become more essential when considered in the light of its application to emergency repairs, let us use as an example a trench, or dewatering, pump. In one form or another a trench pump, hand- or power-driven, is used by almost every distribution repair crew. Under conditions of normal operation, where time, man power and transportation facilities are not greatly limited, almost any form of

FIG. 1. Portable Self-Priming Pump, capacity—15,000 gal. per hr.

trench pump *can* be used to get the water out of an excavation and keep it out so that the men can get in and perform their work. Under emergency conditions, however, the pumping equipment must be viewed in a different light. Power drive is essential—it is self-evident that where man power will be limited, only a unit with power-drive can be considered as suitable equipment.

Under emergency conditions, portability is also an essential characteristic of a trench pump or of any other equipment. It must be capable of being handled without waste of man power and of being transported quickly to the scene of the emergency by any available means of transportation—probably over streets blocked with debris,

possibly over surfaces where wheels cannot be used, where only by carrying can the equipment be transported to the job (Fig. 1).

To save time and to avoid the necessity of selecting and getting the pump into a location near the water surface, the pump should have the ability to prime itself quickly at high suction lifts. To insure operation under any conditions, the pump should have the ability to handle water containing not only ordinary sand and mud, but also residue from debris of any kind, without clogging.

In emergencies such a pump may be found to have uses other than those to which it is ordinarily put in normal water works' operation—uses such as pumping from an emergency supply to tank trucks or emergency chlorinators or filters, or acting as a booster to supply small outlying sections of the distribution system under conditions of inadequate pressure in the supply mains, or taking water for fire fighting from non-potable sources, when drinking water supply must be conserved.

A portable self-priming pump, capable of priming itself at maximum suction lift and capable of handling water containing a high percentage of solids, is one item of equipment now available, valuable in normal operations and extremely important as emergency equipment.

In any major emergency the damage to utility services will probably not be limited to water mains. In the place where men may have to repair a water break it is probable that sewers and gas mains have also been disrupted, filling the locale with toxic gases so that it is unsafe or impossible for the water crew to do their work until these gases are cleared away and ventilation provided. A portable gasoline engine driven blower (Fig. 2) of a type now in use by many sewer departments, gas companies and telephone and electric distribution crews can be used to safeguard the men by blowing in fresh air and clearing away the gases and fumes.

## Portable Light and Power Plants

Blackouts are a part of almost every major emergency—not necessarily the intentional blackout for protection from air raids, but also the unintentional blackout caused by damage to power lines. Even without these blackouts, however, a night repair job usually entails working without sufficient light, unless the repair crew carries its own source of electric power, as shown in Fig. 3. Portable gasoline-engine-driven generators provide such power. Many municipal

FIG. 2. Portable Gasoline-Engine-Driven Blower, for ventilating manholes, tunnels and excavations

FIG. 3. Portable Generator and Floodlights in Position on Emergency Repair Job

water departments and private water companies are now using generators of this type on any night jobs they are called upon to do.

The value of such lighting equipment in emergency repair work is so self evident that no time need be taken to describe its application. Here again, however, it is important to point out some of the characteristics of such power plants which are necessary to their greatest

FIG. 4

FIG. 5

FIG. 4. Transportation of Portable Generator and Floodlight
FIG. 5. Electric-Driven Power Wrench Operating a Water Main Tapping Machine

usefulness in emergency conditions. Portability is important, not portability of a unit so heavy as to have to be provided with wheels, but portability that allows it to be carried over debris piles, and other places where wheels are of no help, by one or two men. Usually light must be on the job first—to size up the situation, to enable the supervisor to direct the work, to permit cleaning up of the debris, opening the site so repair work can be begun. As an emergency tool a power plant which is truly portable (Fig. 4) should be selected.


FIG. 6. Operation of Large Gate Valve with Power Drive and Portable Generator

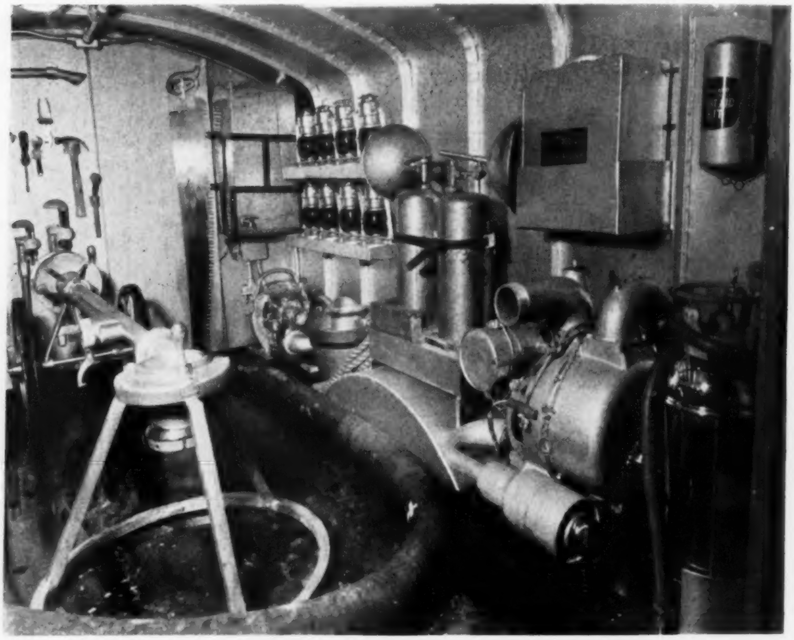


FIG. 7. Interior of a Well-Equipped Emergency Repair Truck; showing portable pump and generator and valve operating equipment

Dependability is important. Equipment which is not ready to be operated at any time, in any weather, is worse than no equipment at all. Automatic voltage control is also important. Loss of one man's time to watch the generator and adjust the voltage to keep from burning out light bulbs is unnecessary if modern equipment is provided.

Portable electric lighting plants, while considered a repair tool of the distribution department, also have been and can be used in emergencies by other water works departments. Where protective lighting is installed around important storage or purifying or pumping plants as a defense against sabotage, failure of commercial power can nullify such protection. With commercial power off, a portable lighting plant can provide for continuance of the lighting. Such a portable plant can also provide the necessary light to facilitate switching from regular to auxiliary power units for pump drives and to light pumping stations or purifying plants while commercial electric power supply is off and the plant is being operated on auxiliary gas-engine or diesel-engine drives.

## Application of Power Tools

Equipped with a portable electric power plant, repair crews are in a position to use portable electric tools on repair or reconstruction jobs. This opens a broad new view for power equipment on such work. Through the availability of portable electric power, many operations now done by hand may in the near future be done by power. There is space here to mention but a few instances where electric power tools are already being used and where they are being developed and are still in trial stages.

In a recent editorial on the subject of defense, one suggestion as a preparation for emergencies was: "Installation of an adequate number of hydrants and valves . . . valves that can be quickly and easily operated." Installation of more hydrants and valves in existing systems means the making of taps in present mains. Many such taps are being made by hand-powered machines. By the use of an electric drill and a gear reduction unit, such hand machines can be operated by electric power, with a saving in time and man power (Fig. 5).

Greater speed in the operation of valves, with less man power, can be provided with the same portable gear reduction unit or power wrench (Fig. 6). Several types of such portable power wrenches on

valve operating drives are available and in use today, with a portable generator as the source of electricity for operation of the power drive.

Electric hand saws are being used experimentally for cutting large mains. Using an abrasive disc saw blade, cast-iron mains have been cut off smoothly and accurately in less time than could be accomplished with a hammer, chisel and wedges. Also, a power hack saw has been developed and used experimentally with success. This saw is constructed on a frame which clamps to the main and provides for cutting at 90 degrees or at an angle to the axis of the main. Electric hammers, too, are beginning to be used for calking bell and spigot joints at a great saving of time over hand calking.

Under emergency conditions, which might be caused by aerial bombing, emergency equipment should be available for transmission of messages. A radio system with portable power plants as a source of power will provide such communication between stations, yards and department trucks and crews in the field.

## Temporary Make-Ups and Line Caps

***By Clinton Inglee***

For many years in the water main cleaning business, use has been made of temporary make-ups which, in emergencies during cleaning operations, make possible the quick restoration of service. These make-ups have been designed particularly for application during the cleaning of mains but could be applied equally well for the temporary connection of mains which have been broken from any other cause.

The make-ups are rather simple devices, consisting of two sections of steel pipe of smaller diameter than the broken main, with cylindrical rubber sleeves at each threaded end. After introduction into the cut or broken pipe, the two sections are quickly joined by two swing bolts, and the rubber sleeves compressed against the interior pipe walls by means of a castellated nut, making a pressure-tight joint. The reduction in diameter for so short a distance does not materially restrict the flow of water.

Dresser line caps have been adapted to certain water main cleaning requirements by welding standard fire hose nipples to the convex surfaces. Where the break is not too irregular, two of these line caps with a connecting fire hose can be used to give service across almost any length of break.

FIG. 8. Expansion Plug and Load Binder; plug may be inserted into broken pipe end for any distance, up to the handle, which is then revolved to squeeze the rubber cylinder against the pipe wall; load binder may be used to prevent plug from being forced out by water pressure.

FIG. 9. Make-Ups of 4-, 6- and 8-inch Pipes; showing wrench used to set up castellated nuts

Figures 8 through 12 show some of the equipment used in these methods of emergency repairs. An illustration of their value as against other methods of restoring service is given in Fig. 13. Shown in the figure is the arrangement for bypassing the break, *B*, through Lines *X*, *Y* and *Z*. With Valves *A* and *C* closed under this plan, however, it is possible that services of great importance might be

Fig. 10. Joint at Middle of Make-Up; disc shown may or may not be used

Fig. 11. Make-Up in Position; showing fire hose connection

interrupted between those valves and the break. Expansion plugs at the break would restore such services rapidly, as Valves *A* and *C* could then be opened. Also, in the event that bypassing through *X*, *Y* and *Z* should be impossible, the use of line caps and fire hose, or make-ups and fire hose, would take care of requirements without difficulty.

FIG. 12. Use of Half the Make-Up as a Plug for Introduction of Water Into Line Through Hose Nipple

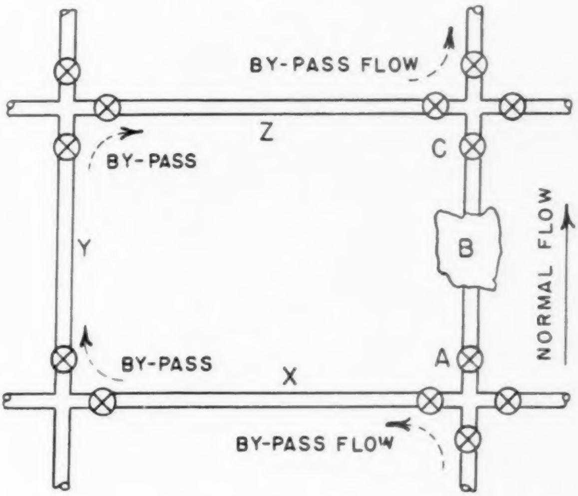



FIG. 13. Arrangement for Bypassing a Break in a Typical City Block

## Main and Joint Repair Equipment

*By Rossiter S. Scott*

In case of disruption of water main service, from whatever cause, the natural number-one objective is to restore the service as speedily as possible; and, with the use of the ordinary stock type of repair equipment, with such adjunctive material in combination as will adequately and speedily meet emergency requirements.

There are a number of combinations of pipe, mechanical bolted type of pipe joints and joint repair devices now regularly supplied to water works departments which can be harmonized to restore water service substantially and speedily after its disruption. In certain cases of defense emergency repair, it is difficult if not impractical to adhere solely to the familiar stock type of repair devices without some modification of them—because of the paramount factor of speed of restoration which rules the design in any emergency restoration plan.

The several accompanying views are illustrative of available emergency repair equipment and adjunctive material for use in restoring water main service, considering both large and small pipe sizes.

The emergency repair combinations treated in this paper are primarily based on the use of the mechanical sleeve type of bolted coupling of flexible design, and upon the use of the adjustable segment type bell joint repair clamp.

Figure 14 shows the familiar style of sleeve type coupling, consisting merely of conjunctive rings bolted together to form the coupling unit when assembled on plain end pipe, the unit consisting of a flared end middle ring, two wedge section rubber compound gaskets for giving positive joint pack with joint flexibility, and two follower rings with the necessary number of connecting bolts to compress the gaskets in place between the middle ring and the adjoining pipe ends therein. This design of coupling when required to have an extra long middle ring, beyond standard length, is designated as a "long sleeve coupling"; and it also may be used as a "line cap" when a blank-flange piece is properly welded in place on one of its ends.

Figure 15 shows a reducer coupling designed on the same principle as the coupling shown in Fig. 14. This reducer coupling is used to

FIG. 14. Sleeve Type of Coupling

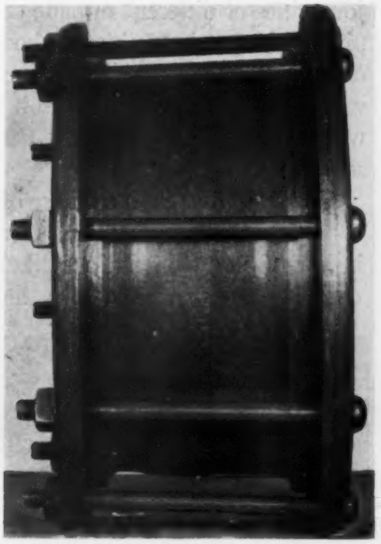


FIG. 15. Reducer Coupling

FIG. 16. Use of Two Sleeve Couplings to Make a Closure

join pipes of different outside diameters; but principally to join steel pipe with cast-iron pipe in the same sizes, when they have different outside diameters. This reducer type of bolted coupling and its variations are quite serviceable in connection with emergency repair work, and, therefore, can be used to great advantage for temporary service.

Figure 16 illustrates the use of two couplings, of the standard sleeve type to make a final closure piece. Valves or fittings can be inserted in the piping system in a like manner; but for such purposes the couplings are furnished with their usual *center-stops removed* to enable

Fig. 17

Fig. 18

Fig. 17. Assembling the Segmental Type of Bell Joint Repair Clamp
Fig. 18. The Bell Joint Clamp in Place

the middle ring of the coupling, as well as all other coupling ring parts, to be pushed back or forward over the adjoining pipe ends preliminarily in the case of either making or unmaking the joint. This method of inserting pipe lengths, valves, fittings, etc., by sleeving them into the existing piping system serves emergency usages in the restoration of water service after a disruption.

Some water works systems are fortunate in having valves so located that each city block can be isolated from the main distribution system without affecting the water service in other or to other city blocks in the vicinity. Such an organized valve system naturally facilitates repairs necessitated by broken mains in any affected city block, while not affecting the water service in the intact portion of the

water main system. No doubt many cities have cases where additional valve insertions within the distribution system would greatly contribute to the speed of restoring broken water mains within certain vital areas, should such breakage occur.

Figures 17 and 18 are intended to illustrate fully the adjustability feature of the segmental type of bell joint repair clamp, which plays an important part in this suggested water service restoration plan. Figure 17 shows this clamp in process of assemblage as a repair to the bell and spigot joint. The spigot ring or follower ring of this clamp has a wide range of adjustment through the use of clips which have fillers, while the bell ring or anchor ring has two of its adjacent segments serrated for adjustably joining with segment bolt, thus providing an easy means of circumferential adjustments for making a snug fit on the bell for different outside diameters of bell. The large reverse wedge section gasket extends well up the face of the bell and is confined in a manner to provide maximum sealing efficiency plus joint flexibility. Figure 18 shows this bell joint clamp connected in place.

## Rehabilitation of Shattered Mains

Figure 19 shows the effect of an earthquake on a water tank. It will be observed in the picture that, although the water tank is considerably wrecked, the 24-inch coupled pipe connection to the water tank remained undisturbed. This picture is included for the express purpose of illustrating the shock absorbing value of the rubber packed sleeve type couplings and the behavior of these flexible couplings under extreme earth disturbance and vibration.

From information gathered from British Government bulletins, there is not any doubt about the extreme vibrations set up by shock transmission waves through the earth when a bomb opens up a crater which may be 35 to 50 ft. or more in diameter. One bulletin further states that: "Rupture of cast-iron water mains may occur at points fifteen or twenty feet from the point of a bomb explosion; apart from the bursting of the mains owing to a direct hit."

In the case of a badly shattered cast-iron pipe, from whatever cause, the chances are that the smashed portion will show very jagged ends with the possibility of having fine cracks, one or more of which may extend quite some distance along the barrel of the pipe section from the broken-off end and possibly well beyond the jagged portion. Just what proportion of a shattered pipe will be found defective or

sound cannot be foretold. It therefore seems logical, for attaining a maximum speed in rehabilitating the shattered water main and for renewal of service, to sleeve over the jagged pipe end or broken portion, so as to enclose completely the entire defective portion, as it exists, and to go on from there as is later explained. The necessity

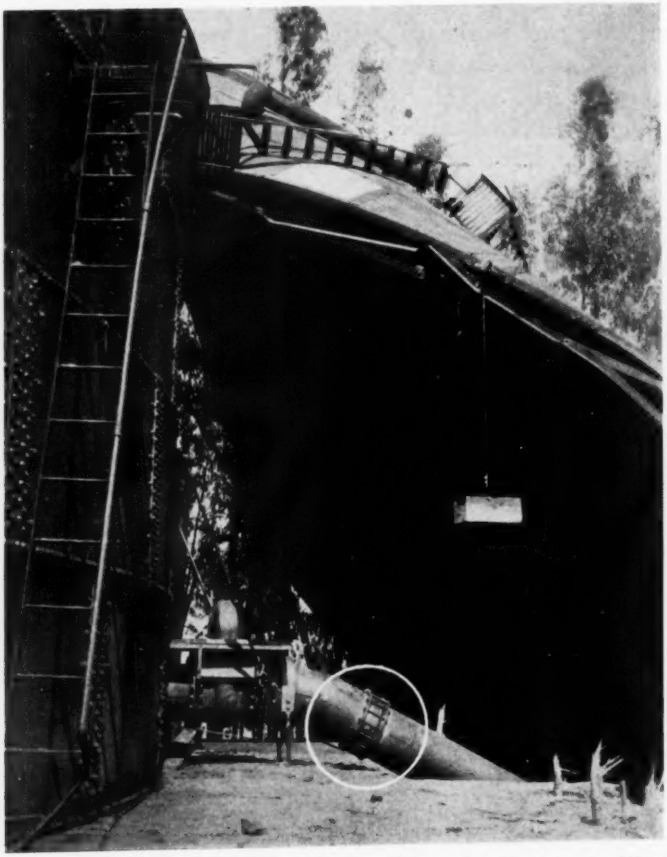


FIG. 19. The 24-Inch Coupled Pipe Connection Remains Undisturbed While the Water Tank Itself Is Wrecked by an Earthquake

for sledging-out and removing a shattered pipe, or broken pieces of it, before starting on a total repair, may occasionally occur. Avoiding this time-absorbing activity by sleeving over the shattered pipe ends and then joining the rehabilitated ends with in-between new pipe coupled thereto is thought to offer the speediest method of renewing

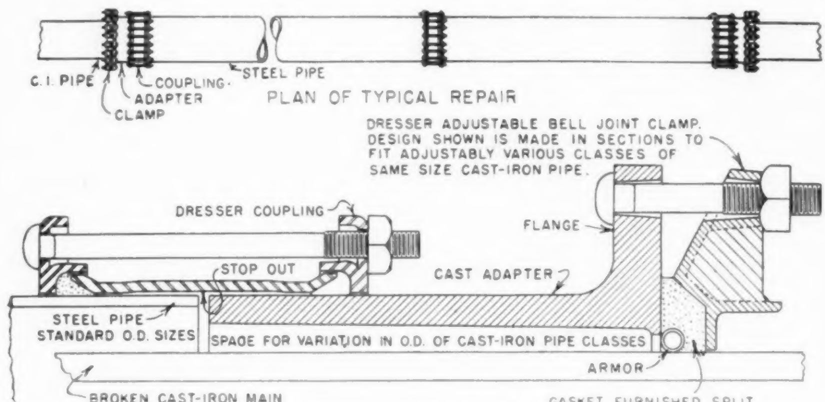
the disrupted water service. In the case where a cast-iron pipe length is not completely shattered, but a bell end is left intact, a proper length (short piece) of plain end cast-iron pipe can be placed in that bell and the new bell and spigot joint roped and faced with lead wool and then clamped with an adjustable bell joint repair clamp such as shown in Fig. 18, using the armored gasket device shown in Fig. 20. The other end of the short piece of plain end cast-iron pipe would then be sleeved over and suitably connected by continuing the process as shown in Fig. 20. Steel pipe is suggested for sleeving-over usage principally because steel is lighter to handle than cast-iron pipe and consequently facilitates speed of rehabilitation in renewal of water service.

The proposed sleeving-over method of repair, for speedy renewal of disrupted water main service, consists of items of equipment of the sleeve type of design including pipes, couplings and clamps, mechanically joined together, according to a repair plan.

Figure 20 illustrates the sleeving-over repair plan for speeding the repair of shattered water mains. The drawing is quite self explanatory. The shattered pipe ends are covered with sleeving-over equipment and then these two rehabilitated ends are finally joined together by using the necessary in-between coupled pipe as shown. In a great many water distribution systems Class B cast-iron pipe is preponderant; however, there are some water systems which contain a considerable amount of Class C and Class D cast-iron pipe. A very few water systems include Class A cast-iron pipe. It is advantageous, however, to have a type of pipe joint combination for emergency repairs that will serve to rehabilitate any shattered pipe size whether the class of pipe involved is found to be, or is, Class A, B, C or D. Figure 20, Sectional View, illustrates this utility feature in a repair clamp combination suitable for use in connecting with either Class A, B, C or D cast-iron pipe of the same size.

The tabulation in Fig. 20 gives the corresponding *outside diameters* of standard steel pipe of the various sizes which can be used for sleeving-over the jagged or broken ends and cracks in the shattered end of shattered cast-iron pipe, these sleeving-over steel pipe sections of suitable length to be joined to the cast adapter pieces and to the adjoining steel pipe sections in the manner shown in the drawing of Fig. 20 so as finally to fill in the gap between any two rehabilitating adapter pieces where called for in the restoration plan to renew the disrupted water service. The comparatively lighter weight steel

pipe with plain ends can be handled more quickly than cast-iron pipe for emergency repairs, and also it can be more quickly cut in the field to secure any desired length, and facilitates making closures. Steel pipe has the additional advantage of being furnished in 40- or 50-foot lengths where needed, as may be the case to span a bomb crater. The use of steel pipe as suggested in this emergency repair plan lends itself to fitting to the cast adapter pieces of the adjustable joint clamp serving Classes A, B, C and D pipe of the same size, and for final




| NOM. C.I. PIPE SIZE | STEEL PIPE O.D | STEEL PIPE THICKNESS | STEEL PIPE I.D. |
|---|---|---|---|
| 3 | 5 9/16 | 0.258 | 5.047 |
| 4 | 6 5/8 | 0.280 | 6.065 |
| 6 | 8 5/8 | 3/16 | 8 1/4 |
| 8 | 10 3/4 | 3/16 | 10 3/8 |
| 10 | 12 3/4 | 3/16 | 12 3/8 |
| 12 | 15 | 1/4 | 14 1/2 |
| 14 | 18 | 1/4 | 17 1/2 |
| 16 | 20 | 1/4 | 19 1/2 |
| 18 | 22 | 1/4 | 21 1/2 |
| 20 | 24 | 1/4 | 23 1/2 |
| 24 | 28 1/2 | 1/4 | 28 |

FIG. 20. Sleeving-Over Repair Plan

in-between connections of the steel pipe with the use of the standard sleeve type couplings, all as shown in Fig. 20.

In water main sizes of 24 in. and under, it appears advantageous to preserve the initial bore of the pipe to avoid a curtailment of the original carrying capacity, instead of attempting to make repairs with the use of reducer-fittings in the case of the smaller sized water mains. Reducer fittings are apt to multiply in a water distribution system repair plan before it is realized, and possibly to result in an undesirable choking down of the original supply volume in some vital

area. In the case of the larger diameters of pipe (above 24 in. in size) the use of reducers is not so much of a factor in the reduction of water main capacity when used for emergency repair.

[Since the A.W.W.A. Convention, a still speedier assemblage of the combination-joint than the initial assemblage scheme appearing in the sectional view of Fig. 20 has been developed. It eliminates the use of a cast adapter by the substitution of a steel ring-plate having a concentric opening of such diameter as will allow Classes A, B, C and D cast-iron pipe, of the same nominal size, to enter and pass through it. The ring-plate (of $\frac{1}{4}$ in. or $\frac{3}{8}$ in. steel thickness) is welded on to one end of the steel middle-ring of a Standard Sleeve-Type Coupling.

This modification was suggested by C. S. Goldsmith, Assistant Engineer of Distribution, Brooklyn Union Gas Company, who has demonstrated its effectiveness in this sleeve-over method for speeding emergency repairs. (The modification drawing was received too late for publication in this issue of the JOURNAL.)]

In Fig. 21 is shown the suggested emergency plan for rehabilitating shattered cast-iron mains in the larger sizes (above 24 in.) with the use of steel reducers furnished with bolted coupling ends, which assembled fitting can be ordered to suit the outside diameter steel pipe which is to connect with corresponding sizes of reducer ends, as illustrated in the top portion of Fig. 21. In the lower view in Fig. 21 is shown the method of sleeving over the class of large diameter cast-iron pipe, as used in the local water main system, when the cast-iron pipe has become shattered. (See Table 1 for the outside diameters of steel pipe sleeves for use in sleeving over a shattered end of cast-iron pipe classes of the same size and in the larger sizes up to 60 in. inclusive.)

Figure 22 illustrates a steel reducer having bolted coupling ends, so that the larger size steel mains can be promptly re-connected should any steel pipe section be badly damaged by some directly applied outside force of sufficient strength. It will be noticed in Figs. 21 and 22 that the reducers are designed to avoid having more than three pipe sizes in stock for emergency repair purposes, these reduced pipe sizes being 48 in., 30 in. and 24 in. in diameter. Naturally, the reducers ordered for stock would correspond to the *outside diameters* of the pipes they are to connect.

The mechanical method of joining pipe with rubber packed sleeve type couplings and flexible type adjustable clamps, for emergency repair work, embodies a number of important factors. The joints

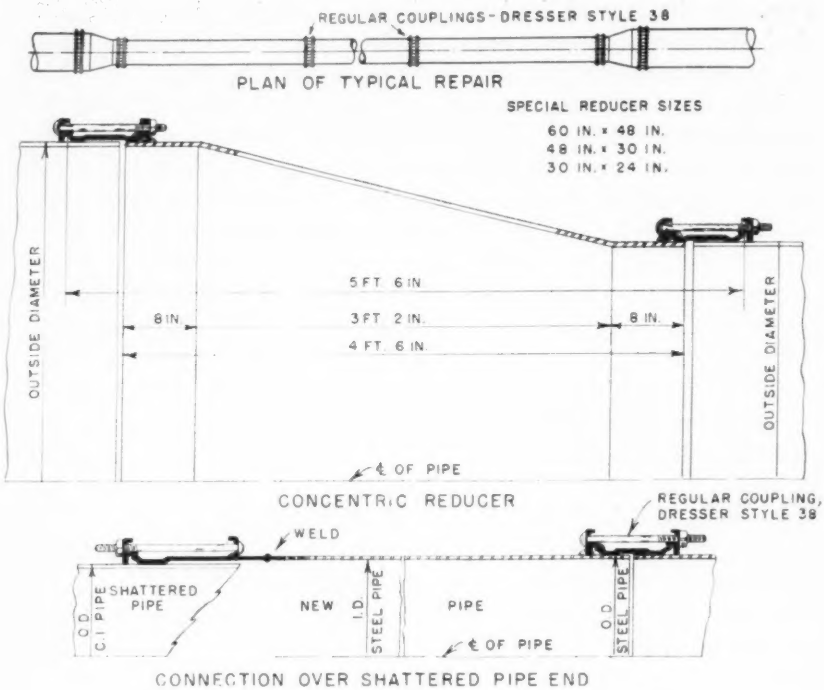



FIG. 21. Plan for Rehabilitating Large Cast-Iron Mains

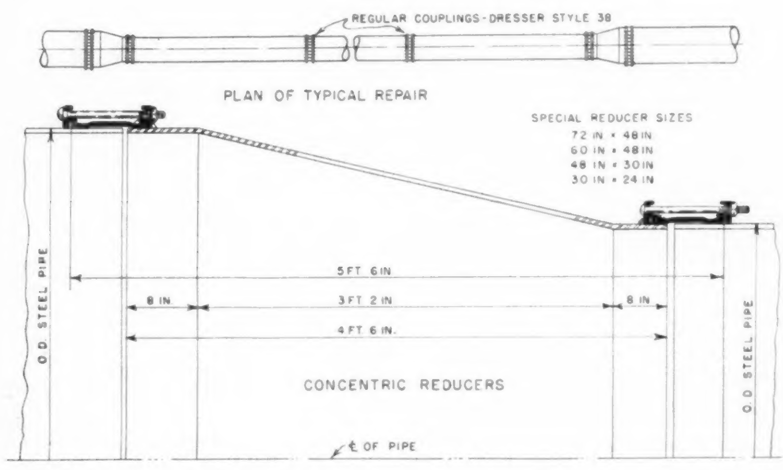



FIG. 22. Plan for Rehabilitating a Steel Pipe Section

are quickly made and their flexibility is a great asset since pipe settlement from loose disrupted earth, and newly filled ground must be expected. Moreover, these joints can be made when conditions

TABLE 1

*Steel Sleeves—As Pipe-Section Connections Over Cast-Iron Pipe of 30 in. and More in Diameter*

| CAST-IRON PIPE | | | STEEL SLEEVE | | | |
|---|---|---|---|---|---|---|
| Size *inches* | Class | O.D. *inches* | I.D. *inches* | Wall *inches* | O.D. Decimals *inches* | O.D. Fractions *inches* |
| 30 | A | 31.74 | 32.00 | | 32.50 | $32\frac{1}{2}$ |
| 30 | B | 32.00 | 32.25 | $\frac{1}{4}$ | 32.75 | $32\frac{3}{4}$ |
| 30 | C | 32.40 | 32.6875 | | 33.1875 | $33\frac{3}{16}$ |
| 30 | D | 32.74 | 33.00 | | 33.50 | $33\frac{1}{2}$ |
| 36 | A | 37.96 | 38.25 | | 38.75 | $38\frac{3}{4}$ |
| 36 | B | 38.30 | 38.625 | $\frac{1}{4}$ | 39.125 | $39\frac{1}{8}$ |
| 36 | C | 38.70 | 39.00 | | 39.50 | $39\frac{1}{2}$ |
| 36 | D | 39.16 | 39.50 | | 40.00 | 40 |
| 42 | A | 44.20 | 44.50 | | 45.125 | $45\frac{1}{8}$ |
| 42 | B | 44.50 | 44.8125 | $\frac{5}{16}$ | 45.4375 | $45\frac{7}{16}$ |
| 42 | C | 45.10 | 45.375 | | 46.00 | 46 |
| 42 | D | 45.58 | 45.875 | | 46.50 | $46\frac{1}{2}$ |
| 48 | A | 50.50 | 50.8125 | | 51.4375 | $51\frac{7}{16}$ |
| 48 | B | 50.80 | 51.125 | $\frac{5}{16}$ | 51.75 | $51\frac{3}{4}$ |
| 48 | C | 51.40 | 51.6875 | | 52.3125 | $51\frac{5}{16}$ |
| 48 | D | 51.98 | 52.375 | | 53.00 | 53 |
| 54 | A | 56.66 | 57.00 | | 57.750 | $57\frac{3}{4}$ |
| 54 | B | 57.10 | 57.4375 | $\frac{3}{8}$ | 58.1875 | $58\frac{3}{16}$ |
| 54 | C | 57.80 | 58.125 | | 58.875 | $58\frac{7}{8}$ |
| 54 | D | 58.40 | 58.750 | | 59.50 | $59\frac{1}{2}$ |
| 60 | A | 62.80 | 63.1875 | | 64.1875 | $64\frac{3}{16}$ |
| 60 | B | 63.40 | 63.75 | $\frac{1}{2}$ | 64.75 | $64\frac{3}{4}$ |
| 60 | C | 64.20 | 64.5625 | | 65.5625 | $65\frac{9}{16}$ |
| 60 | D | 64.82 | 65.1875 | | 66.1875 | $66\frac{3}{16}$ |

are the most unfavorable, and the only tool required on the repair job, for the make-up of the bolted type flexible joint, as illustrated herein, is a ratchet wrench in the hands of any ordinary laborer or "rookie."

The suggested mechanical methods of emergency pipe joining as embodied in this paper are of course subject to such variations, dimensional and otherwise, as will necessarily conform to existing local piping installation. However, the seriousness of a disrupted water supply, from whatever cause, naturally calls for some definite advance plan of organization combined with local resourcefulness in order to have an emergency repair system that will work to the best advantage in speeding up the restoration of service.

## Emergency Repairs to Distribution Systems

***By H. Y. Carson***

Water works men in both Canada and the United States will be interested at this time in mechanical joints, especially for emergency work.

We are primarily interested at present, in emergency work involving speed of laying new pipe lines or even more speed in making emergency repairs. Yet much that we say about mechanical joints can rightly apply to modern good engineering in water works construction of cast-iron mains under city streets.

Our present day "mechanical joint" on cast-iron pipe has been in use for perhaps a hundred years and was known as a bolted stuffing-box type, having a rubber gasket of comparatively large cross-section and suitable follower gland member with bolts to compress the rubber. Manufacturers of cast-iron pipe illustrate several similar designs in their published catalogs today. The writer believes that water works men are now coming to favor these mechanical joints to the same extent as do gas men.

Rubber has been used so long in pipe joints that its name even was different. In this country patents were taken out for a method of heating a rubber compound to vulcanize it as early as 1839—over 100 years ago. In Europe, especially in France, the name for such material was "caoutchouc," both prior to and for some time after 1839. Authentic records indicate such materials used in joints at least as far back as 1850, and by 1870 gas engineers and others interested in laying cast-iron mains described these bolted "mechanical" joints as being very satisfactory.

The bolts used were wrought iron and later reports indicate that the bolts had a limited life. This we now know to be due to galvanic

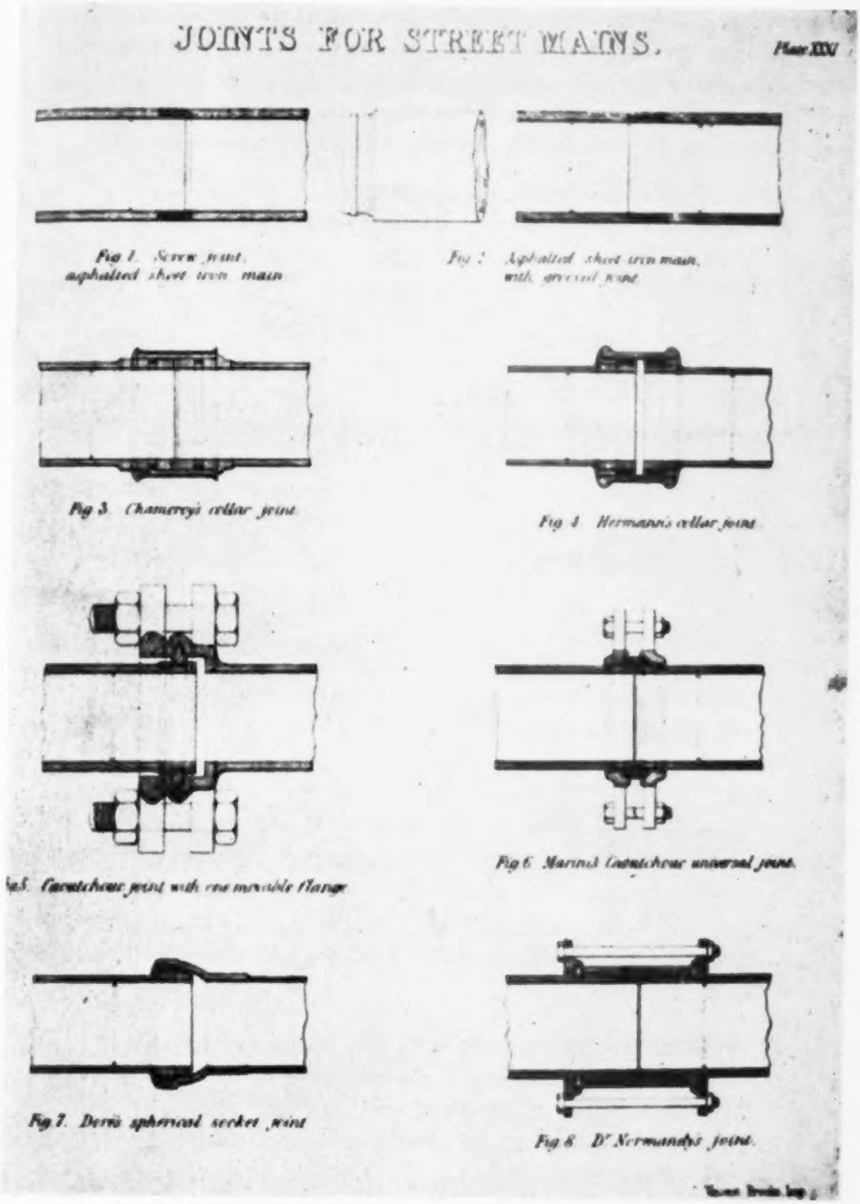



FIG. 23. Page of Illustrations of Pipe Line Construction in 1866; from book by Samuel Clegg, Jr., published in London, England, in 1866. Shows mechanical joint not unlike types now in use.

corrosion. The rubber compounds showed little or no deterioration. Steel bolts were later found to be less serviceable than the earlier wrought-iron material in cast-iron pipe joints.

The prime elements to consider when dealing with modern jointing cast-iron pipe for both regular installations and emergencies are:

1. Low cost—both pipe and joints.
2. Speed and simplicity—minimum apparatus.
3. Repairability.
4. Life equal to pipe—100 years or more.

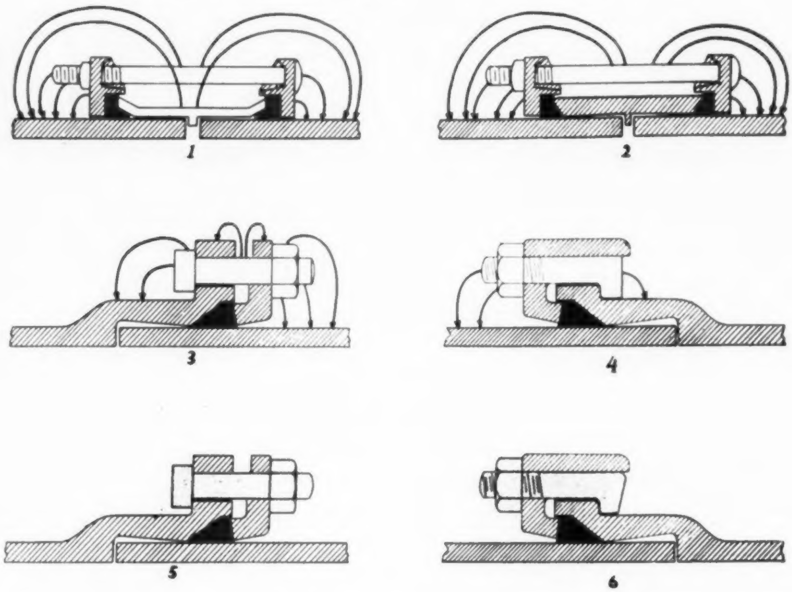



FIG. 24. Evolution of Mechanical Joint, with arrows showing direction and intensity of galvanic corrosion caused by wrought-iron and steel bolts used in jointing cast-iron pipe.

5. Strength greater than pipe—ability to resist shock.
6. Availability of materials, including tools.
7. Minimum parts—a one-piece joint is ideal.
8. Interchangeability or standardization, including pipe, fittings and valves.
9. Flexibility in pipe line for laying and soil movement.
10. Ability to stand future conditions (the trend is for higher pressure and increased service and more severe chemical and physical reaction on all piping).

These ideals in cast-iron piping are largely made possible by the development of cast-iron bolts for underground joints. The physical properties of these bolts (known as C-60 Charcoal Cast Iron) are as follows:

| | |
|---|---|
| Ultimate tensile strength | 65,000 to 75,000 lb./sq.in. |
| Yield point (A.S.T.M. test bar) | 50,000 to 55,000 lb./sq.in. |
| Elongation (A.S.T.M. test bar) | 6 to 9 per cent in 2 in. |

Such cast-iron bolts have been available since about 1921, or one-fifth of a century. Inspections indicate no corrosive or other deterioration, and to date, not one reported case of failure.

Under emergency conditions where breaks in mains occur as a result of floods, earthquakes or destructive acts of war, a coupling for pipes which can be rapidly installed and, at the same time, be expected to give long and useful service is a valuable adjunct to the water works man's stock of materials.

British emergency practice during the present war has shown much value in the bolted on, sleeve-type, rubber-gasketed coupling. It is clear that these emergency repair units are not simply a temporary repair part, but can be so installed as to be useful for many years to come.

# Revising the U. S. Standards for Drinking Water Quality

***A Symposium by J. K. Hoskins, Charles R. Cox, George D. Norcom and John R. Baylis***

## Some Considerations in the Revision

***By J. K. Hoskins***

THERE has been general insistence that there should be effected a revision of the present Treasury Department Drinking Water Standards. These standards, first adopted October 21, 1925, relate to the drinking and culinary water supplied by common carriers in interstate commerce. Accordingly, the Surgeon General of the Public Health Service has appointed an advisory committee to consider desirable changes in the present text of the standards. Each national organization interested in some phase of the subject is believed represented by membership on this advisory committee. To facilitate action, a small sub-committee of Service officers was designated to prepare a preliminary statement of suggested revisions that might be considered by the advisory committee. This first draft of suggested modifications has been prepared by the sub-committee and transmitted to the full committee membership for their review and comment. It is desired that a full and complete

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A symposium presented on June 24, 1941, at the Toronto Convention by J. K. Hoskins, Senior Sanitary Engineer, U. S. Public Health Service, Washington, D. C.; Charles R. Cox, Chief, Bureau of Water Supply, Division of Sanitation, State Dept. Health, Albany, N. Y.; George D. Norcom, Consulting Sanitary Engineer and Chemist, New York, N. Y.; and John R. Baylis, Physical Chemist, Bureau of Engineering, Chicago, Ill. Abel Wolman, Professor of Sanitary Engineering, Johns Hopkins University, Baltimore, participated in the symposium with a discussion that is included in the stenotypist's record which in edited form will appear in the December JOURNAL. *Other discussions are invited.* Discussions should reach A. W. W. A. headquarters by November 10.

discussion of the proposed changes be had by each organization interested in the production and safety of our drinking water supplies, through the agency of its member on the advisory committee. With this objective in view, it is proposed to discuss here some of the changes in statement of the standards that are under consideration.

## Proposed Changes in Bacteriological Requirements

Improvements in bacteriological technique, particularly for determination of the coliform group and the interpretation of the results, have indicated the advisability of modifying the statement of the bacterial part of the standard to conform more nearly with accepted practices. It should be stated that no material increase in the stringency of the standard is contemplated. There is no evidence available that waters which are produced in conformance with the present requirements transmit disease. In fact the evidence is quite to the contrary.

There are, however, certain features of the bacteriological requirements under consideration. One of these concerns the examination of larger portions than the 10 ml. size now specified. Where the coliform density is approximately one per 100 ml. of sample (the upper limit permitted by the present Standard), it can be shown readily that the examination of 10 ml. portions does not permit the detection of the coliform group by the dilution method in this range. By increasing the size of portion examined, this difficulty is overcome and the result may indicate an approach to the limiting value permitted by the standard and consequently permit the inauguration of remedial measures before the permissible bacterial limit is exceeded.

It seems desirable also to avoid the occurrence of periodic breaks in the bacterial quality of approved supplies, which lapses now are possible because results are averaged over long periods. It is being suggested that the period for averages be limited to one month. In other words, that for approval, any water supply involved should meet both requirements of the Standard during any one month. However, when a result is indicative of significant pollution, it is suggested that at least daily samples be examined until satisfactory bacterial quality is again attained.

It is believed advisable also that due attention should be given to the water quality as delivered to the consumer, and not alone at the inlet of the distribution system. It is proposed, therefore, that a specified minimum number of samples be examined routinely from

various points in the distribution system, this number to be governed by the average daily volume of water delivered.

The need for improvement in the standardization of laboratory techniques to bring procedures into conformity with those approved fully by the American Water Works Association and American Public Health Association is also acknowledged. It is being suggested that laboratories and laboratory methods shall be subject to the inspection of the certifying authority and that failure to comply with specified procedures shall be cause for refusal of certification of the water supply concerned.

### Supplementary Sanitary Requirements

No significant changes have been suggested in that part of the Standard pertaining to "Sources and Protection." Some additions have been proposed to the list of sanitary defects in water systems, as well as supplementary material in an appendix concerning sanitary requirements for water purification and distribution systems. This supplement is intended primarily as a guide for inspecting officers. Consideration is being given also to limiting the bacterial concentrations of raw waters undergoing various types of treatment. These bacterial loads are expressed in terms of allowable maximum densities of coliform bacteria present in the untreated waters. Experience has indicated that there is a very definite relationship between the coliform content of the raw and finished water subjected to any particular type or combination of types of treatment, and that if such loading limits of treatment processes are exceeded, defects in bacterial quality of the effluent will occur.

### Suggested Modifications of Physical and Chemical Requirements

Some changes have been suggested in that part of the standard concerned with "Physical and Chemical Characteristics" in accordance with new facts that have been developed since 1925. These modifications relate to certain toxic metals and their salts, which may occur in water, and to other objectionable substances in waters used for drinking and culinary purposes. Among the objectionable metals being considered for the first time are boron, selenium, and fluoride. The present allowable limits of copper and of zinc might well be raised, and the same is true of caustic alkalinity and of the carbonates of sodium and potassium in over-treated waters. Other chemicals used in treatment processes, the physiological effects of some of which

are not clearly determinable at this time, should be avoided in excess. Thus free chlorine, chloramine, caustic alkalinity, the phosphates, etc., it is believed, should not be present in excessive amounts.

### Acceptance of a Revised Standard

It is realized that all the changes proposed will not meet with the unanimous approval of the water works profession. The present Standards do not enjoy such complete acceptance. However, an earnest attempt will be made to develop a reasonable statement of the requirements of a safe, potable drinking water. Our advisory committee members are receptive to constructive criticisms and suggestions concerning the present standards and proposed revisions. The Association membership, through the advisor designated by its officers, has a direct representative to whom its views may be expressed and, moreover, the definite assurance that each will be given every consideration during the formulation of changes which are under discussion. I want to assure you that the sole purpose of the Public Health Service in this activity is one of active co-operation with the profession in the maintenance of the high standards of quality of the drinking water supplies of our country as they are available to common carriers. It is our sincere desire to insure a continuance of the high regard which has been created for the safety, potability, and healthfulness of our public water supplies as a result of the years of faithful and devoted service of the water works profession. Your active support in maintaining these objectives is earnestly solicited.

## Drinking Water Standards

*By Charles R. Cox*

Any review of drinking water standards should consider the subject in a broad manner in order to evaluate properly the many factors involved. Standards as to technical practices, manufacturing procedures, specifications, etc., are well established. In some instances such standards represent minimum requirements with the tacit understanding that actual accomplishments will be better than required. In other instances standards are in the nature of a code of practice or a general guide, without having any binding provisions. Other standards are intended to secure uniform administra-

tive policy by various sub-agencies functioning under a centralized authority. Finally, there are quantitative standards which are rather precise and binding and where only limited discretion is permitted the administrative authority. The nature of the present so-called Treasury Department drinking water standards, enforced by the U. S. Public Health Service now functioning under the Federal Security Agency, include characteristics common to these several types of standards, so that it is evident that disadvantages inherent in any single type are less likely to prevail.

One need not dwell upon the benefits which have resulted from the existing drinking water standards in improving the status of water supplies throughout the country. It seems evident, however, that these benefits would have been much more marked had not the bacterial section of the standards been somewhat over-emphasized to the neglect of the sections dealing with sanitary surveys, equipment, operation, etc. This review, therefore, will deal with the several aspects of the subject which are of greatest importance.

## Application of Standards to Small Supplies

Generally speaking, interest in the technical provisions of the Treasury Department Standards has been in connection with larger supplies under technical control. It should not be overlooked, however, that interstate carriers are served by every type of water supply including wells fitted with hand pumps. For instance, only 73 of the 800 public water supplies in New York State serve interstate carriers, and small wells or springs owned by carriers are used exclusively for this purpose in six instances. Supplies serving communities with populations of less than 500 are used in three instances and those serving populations less than 1,000 are used in four instances. Only 49 of the supplies serve populations exceeding 5,000 and only fifteen served populations exceeding 50,000. The statistics regarding these 79 supplies indicate that 23 secure water from wells or springs whereas the remaining 56 are surface supplies. Treatment by chlorination alone is provided in 39 instances, whereas treatment by filtration and chlorination is provided in 30 instances. In general, these characteristics apply to the remaining of the 800 supplies. It is evident, therefore, that very serious consideration must be given to the peculiar conditions surrounding small supplies in order that drinking water standards may be sufficiently flexible to apply without discretion and at the same time not sufficiently lenient as to be of little value.

## Importance of Flexibility in Standards

In general, standards should be designed to insure safe water supplies and reasonably uniform practices without imposing arbitrary requirements or without impeding administrative judgment. Furthermore, quantitative standards followed by state and federal officials cannot be as rigid as ideals of practices which are serviceable to local officials in charge of specific supplies. The statistical approach to the problem must be followed to aid the technical judgment. The inherent difficulties in the development of quantitative statistical standards, however, are indicated by the experiences in New York State where the "scoring" of public water supplies was previously practiced as part of the appraisal of local public health conditions in the municipalities served. It was found by experience that it was extremely difficult, if not impossible, to assign a quantitative value to many intangible factors such as personnel, the relative protection afforded by natural filtration of ground water as opposed to the artificial filtration of surface water, the allowance which should be made for periodic inspections by consulting chemists, etc. Furthermore, arbitrary values seemed to result from such grading when communities of various sizes were involved, especially when questions as to frequency of sampling, type of laboratory control, etc. were considered. Obviously it could not be expected that smaller municipalities could provide as extensive facilities as larger municipalities, but it was difficult to assign a quantitative value to express the permissible difference. The practice, therefore, was discontinued as being impracticable notwithstanding the inherent desirability of having some measure as to the protection afforded the health of the citizens of the various municipalities. Standards of water quality, however, are of a more circumscribed nature and thus are suitable for quantitative expression if they be supplemented by provisions for the exercise of judgment.

## Need for Standards for Raw Water

The present drinking water standards do not contain provisions limiting the degree of pollution of raw water subject to specified treatment. Inasmuch as the permissible loading of water treatment plants has been very carefully studied for a number of years by the U. S. Public Health Service it is logical for revised drinking water standards to embody certain provisions as to the quality of raw water. There seems to be no uncertainty as to the disclosures re-

sulting from this extensive research, namely, that the density of coliform organisms remaining in the treated water is proportional to the density in the raw water, so that for any given efficiency of water treatment any restriction as to bacterial quality of the treated water implies a corresponding restriction as to the permissible degree of pollution of the raw water. The "efficiency" of treatment disclosed by these studies, that is the "spread" between the bacterial density of the raw and treated waters, would, however, be determined by the efficiency of treatment of the specific supplies studied in the past, and thus the actual efficiency of present or future plants should be greater, if confidence is to be placed upon progress. It is pertinent, therefore, to consider the subject in the light of present trends of water treatment, especially in regard to chlorination.

### Provision for Future Developments in Treatment Methods

Recent important developments have indicated that undue confidence has been placed in the past in the effectiveness of some arbitrary concentration of residual chlorine, such as the range of 0.1 to 0.2 p.p.m. after a 10-minute reaction period, without due weight being given to the influence of oxidation potential, pH, organic content, temperature, reaction time and other variables. As a consequence, the routine control of chlorination with the ortho-tolidine test probably has been faulty in many instances, without the situation being evident to the operator. In other instances the demonstrated defects in chlorination have been attributed at times to inherent limitations in the process or to the influence of chlorine-resistant bacteria.

More information of practical value no doubt could have been secured by the study of the physiochemical state of the chlorine or chlorine compounds, that is the real "activity" of the disinfecting agent in the specific water involved.

The development of super-chlorination and of the "flash" test with the ortho-tolidine reagent have made available a method of maintaining active chlorine of high oxidation potential and of determining approximately the "state" of the chlorine, so that it is now possible to regulate and control chlorination so as to approach 100 per cent removal of coliform organisms even when more heavily polluted waters are treated. Conversely many of the results secured in the past were in the borderline zone where only partial destruction of organisms occurred and when the number of surviving organisms was proportional to the density of organisms in the raw water.

The somewhat technical aspects of chlorination discussed above are supported by the practical experience in the treatment of water. For instance defective chlorination has been found in many cases to be due to faulty operation or equipment, or to the influence of local factors which were overlooked, rather than to the inherent deficiencies in the treatment process. In other words the quality of the chlorinated water is generally satisfactory but occasionally unsatisfactory due to periodic inefficiency in treatment rather than to variations in quality which are correlated directly with concurrent variations in the quality of the raw water. In other instances, of course, chlorination produces "borderline" results where any significant overload leads to ineffective treatment, the remedy being to increase the concentration of residual chlorine maintained in the supply, or some other improvement of this nature.

In other words, one would suspect that ineffective chlorination practice in the past has been due primarily to controllable factors rather than inherent weaknesses of the treatment process and thus such failures in practice necessarily do not always indicate the need for filtration in addition to chlorination.

The efficiency of conventional rapid sand filtration seems to be well established. On the other hand, this efficiency may be increased many fold by the practice of pre- and post-chlorination or by super-chlorination. Conversely the filtration of water insures the more reliable chlorination of heavily polluted surface waters. The important point, however, is that chlorination practice governs any marked increase in credited efficiency of rapid sand filtration plants. Some increase in credited efficiency, therefore, should be allowed for chlorination alone when practiced under conditions similar to pre-chlorination in coagulating basins, where large super-chlorination doses, reaction basins and flexibility in control provide treatment conditions much more reliable than conventional chlorination.

In view of the important factors under discussion, it would appear that any restrictions as to the permissible degree of pollution of raw water should be supplementary to the more specific drinking water standards so that some administrative discretion will be provided to allow for the influence of intangible local factors which are difficult to express in a quantitative manner. Unless this is done the credited efficiency of water treatment plants will be restricted in the future to the accomplishments at the plants used to establish the limiting values and thus no credit will be given to future advances in the science of water treatment.

## Confusion in Standards for Treated Water

The present drinking water standards relating to the permissible content of coliform organisms has been subject to very critical review in connection with the prevalence of water-borne diseases. One should be frank and admit that there are no accurate quantitative data correlating the incidence of water-borne diseases and the precise numerical value assigned to the present bacterial standard. There is very extensive practical evidence, however, that supplies meeting the present bacterial standard are not involved in water-borne outbreaks, provided an adequate number of representative samples are used in determining the bacterial content of the water. For instance, the Committee on Methods of Water Treatment and Laboratory Control of the A. W. W. A. has concluded after several years of study of this subject that the present bacterial standards are satisfactory as a quantitative guide but that there is need for improvement in the sampling of supplies to determine their actual quality and in the application of known methods of water treatment.

One may conclude, therefore, that the average density of coliform organisms implied by the present standards continues to be a satisfactory administrative guide as to sanitary quality.

Granting, therefore, that the implication of the present standards continues to be a satisfactory measure of sanitary quality, the problem is to determine what procedure would be most practical and useful as a measure of such quality. Without discussing the somewhat involved statistical background of this subject, it is significant to note that the problem is: (a) whether emphasis should be placed upon the appraisal of a series of samples as a statistical unit, as in connection with the present standard, or (b) whether the technique used in the examination of each sample should be modified so as to give a statistically definite value for each sample.

There has been considerable confusion regarding the interpretation of the existing drinking water standards. These standards now refer specifically to the permissible number (10 per cent) of 10 ml. portions of a series of samples of water which may contain coliform organisms. No reference is made to the statistical computation of the most probable number of organisms per 100 ml. of water. In fact the most probable number cannot be computed from the results of the examination of a series of samples because such a series does not represent a single statistical entity. Furthermore, the examination

of five 10 ml. portions of a single sample enables the computation of a most probable number no lower than 2.2 per 100 ml. of water, so it would be necessary to examine ten 10 ml. portions of each sample to enable the most probable number of 1.05 per 100 ml. of water being computed.

Notwithstanding this situation, it is frequently assumed that the present standards mean that the most probable number of coliform organisms in a series of samples must be 1.05 or less per 100 ml. of water. It should be emphasized, therefore, that the present standards involve the appraisal of the results secured from the examination of 10 ml. portions of a series of samples of which 10 per cent or less may be positive. A second provision of the standard governs the number (5 per cent) of samples which may have three or more of the five 10 ml. portions positive, so that some restriction rightly is placed upon the degree of pollution of individual samples in a series.

### Objections to Revision of Laboratory Technic

Any change in the standards and the technic followed in the examination of individual samples to enable the most probable number index being computed for each sample, however, is likely to place undue emphasis upon each sample as an individual item rather than upon a series of samples as a whole. This seems to be realized by those preparing the tentative revisions of the drinking water standards, because although the suggested requirement that five 100 ml. portions of each sample be examined is intended to provide definite results for each sample, nevertheless the sanitary quality of the supply will continue to be appraised in the light of the results secured in the examination of a series of 100 ml. portions of samples collected during a period of one month, without any one sample being given specific weight. The only change, therefore, is in the volume of water examined and the accompanying statistical modification. In other words, the essential change is that the old standard permitting 10 per cent or less of the 10 ml. portions of a series of samples may be modified to 60 per cent or less of the 100 ml. portions of a series of samples.

On the other hand, the examination of five 100 ml. portions of a single sample will disclose most probable number values from 0.22 to 1.60 per 100 ml. of water so that a single sample is statistically significant. Furthermore, this procedure provides two values as to bacterial density below the official standard so that information is

provided as to low but possibly increasing concentrations of coliform organisms. In other words, the examination of larger volumes of water enables the computation of approximately the same most probable number index implied by the present standard when 60 per cent or three of the five 100 ml. portions are positive, and also provides two other lower values.

It is pertinent to ask, therefore, whether emphasis should continue to be placed upon the appraisal of a series of samples collected from a supply during a given period, such as one month, for simplicity of sanitary control, or whether the technic followed in the examination of each sample should be modified to permit the most probable number value to be computed for each sample. Laboratories are now equipped with a stock of glassware and other equipment for the examination of 10 ml. portions of water. Furthermore, sampling containers used by state departments of health for the shipment of samples to their central laboratories have been designed on this basis. In addition, emphasis is now being placed upon the examination of a large number of samples collected from distribution systems, which trend would be facilitated by the continued emphasis upon the examination of 10 ml. portions of a series of samples and by the procedure of appraising the sanitary quality of a supply by the percentage of such tubes which are positive for coliform organisms, rather than to modify this administrative procedure to permit the statistical appraisal of a single sample.

In any case, if the latter procedure be adopted in the revised standard, the wording should be modified to apply to the computed most probable number of coliform organisms for each sample in a series. Unless this is done there is no statistical justification of examining 100 ml. portions, except that the results for each sample will give individual values as to the most probable content of coliform organisms in that sample.

In general, therefore, it would seem that the present laboratory procedures and standards as to bacterial quality should be retained, but with greater emphasis upon the examination of a representative series of samples.

## Need for Standardization of Sampling Programs

A recent survey by the "Committee on Water Supply" of the American Public Health Association discloses the very serious discrepancies in the sampling programs used in control of public water

supplies, even those serving large communities. The great need seems to be for a larger number of samples being examined at frequent intervals to indicate more clearly the true quality of the water reaching the public. Furthermore, undue emphasis has been placed upon the examination of the final effluent of filtration plants rather than of samples collected directly from distribution systems. In many instances this is due to the convenience of concentrating analytical control at treatment plants, but in some instances it is suspected that the practice was influenced by the difficulties incidental to secondary pollution of water in distribution systems and reservoirs, and because of the unexplained seasonal increase in the bacterial content of water in closed distribution systems when there was no known exposure to pollution.

This subject has been extensively surveyed independently by Howard, Scott, Baylis and others. Time is not available to discuss the situation in detail, but it is evident that there will be great uncertainty as to the actual quality of the water reaching the public and as to appropriate bacterial standards of such quality as long as there is an unexplained discrepancy between the quality of a treatment plant effluent and the same water as delivered by the distribution system. The chlorination of water leaving open equalizing reservoirs, the maintenance of higher than usual concentrations of residual chlorine in distribution systems and the control of cross-connections and other channels, through which secondary pollution may enter, should be extended. It is doubtful, however, in the present state of our knowledge whether available procedures will be altogether successful in the control of distribution systems. Therefore, pending the needed advance in control procedures, drinking water standards should be sufficiently flexible to permit administrative officers to use their judgment in appraising the significance of secondary pollution.

### Difficulty of Standardizing Operation and Control

The operation and control of public water supplies involve so many intangible human values and variable local conditions that it is impracticable to assign rigid quantitative requirements as to operation and laboratory control. For instance, many small filtration plants are more difficult to operate than some large plants yet funds are not available to provide the expert supervision and extensive laboratory control which are generally recognized as being desirable.

Attempts have been made to surmount these difficulties by training programs and by the stimulus due to the regulations pertaining to the licensing, certification, etc., of water treatment plant operators. It would seem, therefore, that drinking water standards can contain only a code of practice which would be harmonious with the better practices pertaining to control and operation. On the other hand, the incentive given to effective operation and control through the enforcement of drinking water standards justifies greater consideration being given to this subject than was embodied in the existing standards.

### Governmental Control of Public Water Supplies

Inasmuch as we are discussing drinking water standards enacted by the Federal Government and inasmuch as there have been suggestions that the degree of federal control should be intensified in order to improve the status of public water supplies in general and to lead to a greater uniformity throughout the country, it is appropriate to discuss the relative functions of federal and state governments in the supervision of public water supplies. One's attitude towards this subject usually is based upon factors beyond the realm of water supply matters and is largely governed by one's attitude towards centralization of power. Two issues seem to be involved.

First, is detailed governmental control of a compulsory nature needed or desirable, or should the slower but more democratic methods of education, co-operation and example be followed by governmental agencies acting under suitable basic laws giving supervisory powers supplemented by administrative codes? Secondly, should the demand for uniformity of governmental control throughout the nation be met by Congressional action authorizing federal control below the level of interstate activity?

### Limitations of Strict Government Control

One answer to the first question is supplied by the actual accomplishments in the improvement of public water supplies by the present co-operative and educational program supplemented by the use of a limited amount of governmental compulsion by state agencies. Another answer to this question is supplied by the fact that improvements to water supply are not necessarily correlated with the existence or non-existence of rigid laws but rather with administrative accomplishments in the respective states.

An increase in general governmental control is practicable with expanded forces. There is a limit, however, to the group of technical factors which can be subject to detailed control by any governmental agency because of the magnitude of the problem. For instance, it would be a simple matter for state sanitary codes to contain detailed requirements as to water works practices. On the other hand, it would be impracticable for the details as to compliance with such provisions to be determined before a given supply is certified to as satisfactory for use on interstate carriers, because this certification covers a full calendar year duing which many changes may occur in operation, or equipment. Therefore, local water supply officials must assume responsibility as to compliance with codes of practice under the general supervision of enforcing agencies.

## Dual Control by State and Federal Governments

The second question is more complicated. The U. S. Public Health Service acts under the interstate commerce clause of the Constitution and thus its activities are restricted largely to interstate problems. On the other hand, the Service has considerable influence over the activities of the respective states through grants-in-aid which provide control over the use of such funds. In this way the Federal Government is unifying the work in the respective state departments of health without any basic law being involved. This includes state programs for the control of public water supplies. The more specific control of the limited number of water supply systems serving interstate carriers is conducted under the direct provisions of the interstate commerce law, but the field work and technical details as to certification of such supplies is handled by the respective state departments of health working in co-operation with the U.S. Public Health Service. In six instances, however, states or territories have embodied the existing "Treasury Department Standards" in their sanitary codes so as to apply to all public water supplies.

Localized interstate problems, such as the control of an interstate stream, have led to the formation of interstate compacts and commissions in a limited number of instances. Actual supervision has indicated that such agencies in themselves provide administrative control without relieving the states of their duty and authority as constituted in the basic laws of the states. Therefore, the net result is that there is an opportunity for overlapping administrative authority which may be productive of difference of opinion as to policy.

This situation becomes known to municipal authorities directly concerned in the matter, with the result that a passive attitude is adopted by these officials and little is accomplished. More rapid concrete results, therefore, can be secured by active state agencies in position to collaborate with local officials where the problem is not merely one of control but extends to improvement projects and programs for the future. In general, therefore, there would appear to be no need to change the present basic dual control by state and federal agencies, although naturally there is room for improvement in control efforts.

## Summary

Probably there will be no time when the art of water treatment and the control of public water supplies will be sufficiently static to permit provisions of drinking water standards to be based upon universally accepted factors of a permanent nature. Therefore drinking water standards should be sufficiently flexible to allow for technical advancement and yet sufficiently specific to serve as a quantitative guide, provided the sanitary appraisal of a given supply is not hampered by an attempt at unwarranted statistical accuracy.

1. Standards as to drinking water quality should be applicable to all public water supplied and not only to water supplies serving interstate carriers.

2. Such standards should be restricted to factors of generally recognized importance which may be expressed quantitatively, such as bacterial standards, permissible concentrations of toxic substances.

3. The present standards of bacterial quality of water provide a satisfactory numerical measure of sanitary quality whereby a given supply is appraised by the examination of a series of samples examined in accordance with well established procedures to give results which may be interpreted for the series as a whole, rather than undue statistical accuracy being attempted for any one sample through the examination of five 100 ml. portions of each sample.

4. Codes of practice involving many intangible factors difficult of quantitative expression should be separate from mandatory standards as to water quality and should serve as administrative guides but not as restrictions to operating procedures or design features.

5. There is need for basic information as to the significance of apparent bacterial aftergrowths in distribution systems not subject to secondary pollution and of practical methods of improving the control of chlorination before drinking water standards should contain specific requirements as to these factors.

# Revising the U. S. Standards

*By George D. Norcom*

The JOURNAL of the A.W.W.A. for March, 1941, contains a brief announcement that a revision of the Treasury Department Drinking Water Standards is contemplated. Two reasons are given for the proposed revision: first, because many improvements in water supply practice have been adopted since 1925 with increased uniformity of quality and safety; and second, because it is in order for the standards to conform more closely to current requirements for water supplies of attainable safety and potability. It is stated further that in order to carry out such a revision the Surgeon General has appointed a special Advisory Committee.

The writer is not a member of the Advisory Committee and he wishes to make it clear at the outset that he has recognized no need for drastic revisions of these standards in his current duties. Certain minor changes, largely related to the application and interpretation of the standards, are desirable and will be discussed later. It is clear that individual views on revision of the standards must be to a large extent a matter of personal opinion based upon experience and records of performance. The discussion which follows is the viewpoint of an operating executive largely concerned with the quality of water produced by a considerable number of small to medium sized water supply systems.

## Early Water Quality Standards

It may be helpful at this point to review some earlier ideas of water quality control which have developed since the turn of the century. It would appear that the fundamentals of water purification were worked out during the early part of the century, culminating with the introduction of liquid chlorine control apparatus in 1913. It was during this period that devastating epidemics of water-borne intestinal disease were brought under control. Prior to the promulgation of the first Treasury Standard in 1914, procedures for the bacteriological examination of drinking water were extremely variable and interpretation was based largely on individual judgment. It was with these methods of control that great progress was made in the science of

water purification and the conquest of water-borne intestinal disease. The important point to be made here is that this progress was due primarily neither to bacteriological methods of testing nor to any standard of quality, but rather to the inherent and fundamental excellence of the methods of water purification employed. The 1914 standards introduced the so-called "standard sample" consisting of five 10 ml. portions and permitted one out of the five to be positive. This standard was used very widely during the first world war in the control of the quality of water supplied to the armies and a remarkable record of freedom from water-borne disease was established.

### Treasury Standard of 1925

The revised Treasury Standard adopted in 1925 and now under discussion greatly increased the stringency of the bacteriological requirements of the 1914 standard. There is no evidence to show that this revision was brought about by a failure on the part of water plants to produce safe drinking water nor by the occurrence of excessive outbreaks of water-borne disease. The reasoning on this point occurs on Page 2 of U. S. Public Health Service Reprint 1029: "The committee has, therefore, taken this better class of municipal water supplies as its standard of comparison with respect to safety and proposes, as a fair objective, that the water supplies furnished by common carriers. . . . be of comparable safety." So far as is known, no evidence of the failure of the earlier standard was produced nor was the revised standard supported by experimental research on the limits of permissible bacterial impurity.

The standards of 1925, as published in Reprint 1029, constitute a remarkable document in many respects and should be re-read at frequent intervals by those interested in water quality. Its tone is moderate and yet it contains in outline form all of the basic procedures necessary in arriving at a judgment of drinking water quality. The standards include three principal criteria of quality:

1. As to Source and Protection
2. As to Bacteriological Quality
3. As to Physical and Chemical Characteristics.

It should be noted particularly that the report does not recommend rigid enforcement of the standards and provides no penalties for failure to comply, leaving this aspect to the duly constituted local authorities.

The bacteriological standards were automatically made still more stringent in 1936, but not by governmental action. I have reference to the revision of *Standard Methods of Water Analysis* whereby the occurrence of minute bubbles of gas in the fermentation tubes is considered to indicate a positive test instead of relying on the previous 10 per cent requirement. This change resulted in a very definite increase in the number of positive tests reported.

## Adequacy of Existing Standards

The writer's experience with the old and new Treasury Standards dates back to 1915 before the entry of the United States into the first world war. During this period there have been very few instances reported where water supplies which met the standards upon frequent and repeated tests have been suspected of causing water-borne disease. If we except those cases where the raw water became so degraded as a result of drouth or emergency as to be unspeakably filthy, the number of such instances occurring in 25 years are few indeed. Even in the few suspected cases it has been pointed out that there are elements of doubt as to the efficacy of the methods of purification and the complete adequacy of the sampling and testing employed (1). This observer would conclude from his own observations and from the published records that there is no evidence to support a drastic revision of the existing Treasury Standards. This is virtually the same conclusion expressed by H. W. Streeter in a scholarly paper published in 1939 (2).

All of this discussion up to this point is based on the assumption that the bacteriological standard is to be applied to the purified water as it enters the distribution system. It is thus that purification plant performance is measured. Most water purification plants have no difficulty in meeting the standard on this basis; in fact many plants surpass it. The picture changes when the samples are taken from the distribution system where numerous circumstances are at work which are quite beyond the control of the purification plant operator. Among them may be mentioned the effect of open reservoirs, pipe deposits, dead ends, back-siphonage and cross-connections. Unfiltered but disinfected surface supplies are particularly susceptible to disturbances within the mains which result in showings of coliform organisms which sometimes persist for months. Scott (3) has recounted several instances of this type where coliform organisms, believed to be of harmless origin, gained access to distribution systems and caused

failure to meet the standard for considerable periods. It is significant that there were no outbreaks of water-borne disease during these periods. It is evident, however, that the Treasury Standard is not applicable to distribution samples under all conditions.

Previous discussion is also based on the assumption that the bacteriological standards are to be applied to confirmed tests. It has been suggested that a return should be made to the presumptive test in lactose broth as a basis for the standard. This proposal is insupportable in the light of the record. Many plants serving communities with long records of freedom from intestinal disease produce finished waters often showing 50 per cent or more of all 10 ml. tests presumptively positive. It would hardly be possible to relax the standard sufficiently to permit these waters to qualify. It has been shown that practically all of these nonconforming presumptive positives are caused by spore formers and before these organisms can be indicted as agents of water-borne disease evidence as to their pathogenic significance must be established by adequate research.

### Revision of Requirements for Sampling

During the past few years a number of plants have been inoculating 100 ml. portions for comparision with the standard 50 ml. sample. The information obtained has not been particularly illuminating. While it is fully appreciated that the use of five 100 ml. portions of water will permit the calculation of an M.P.N. in the range below 1.05 per 100 ml. it is not clear that this range is critical for the formation of an opinion as to hygienic quality. In fact, it appears that the information to be derived from examining several standard samples composed of five 10 ml. portions each, is more significant than the examination of a single sample of five 100 ml. portions.

The present standard leaves the frequency of sampling largely to the discretion of the plant management and local supervisory authorities. This has resulted in the widest possible variation in sampling frequency and unquestionably has resulted in inadequate bacteriological control in many plants. This is an outstanding weakness and it should be corrected. Any revised standard should specify recommended frequency of sampling in schedules arranged with due regard to size of plant and quality of raw water.

The present bacteriological standard specifies limiting percentages but fails to specify the period of time to be considered. It is common practice to apply the standard to the plant bacteriological record,

first, on a monthly and second, on an annual basis. Most plants comply with the standard on an annual basis with ease, but it may happen that one of the same plants will fail to comply on a monthly basis. This is particularly true in the case of unfiltered, chlorinated gravity supplies where most of the samples are taken from the distribution system. A revised standard should specify the periods of time to be used in applying the standard, but it should be borne in mind that the shorter the period the more difficult will be the compliance.

### Other Modifications Necessary

The subject of cross-connections and back-siphonage in distribution systems should receive careful consideration in a revised standard, but under no circumstances should the water company be saddled with the full responsibility of correcting these situations except with the aid of the police power vested in the local and state authorities.

Certain features of the chemical requirements of the present standard are in need of revision. A limiting value should be placed on the fluorine content of drinking water. The limit for copper content might be relaxed somewhat and the presence of moderate causticity should be permitted. There appears to be no justification for the 50 p.p.m. limit on alkali carbonates.

### Conclusions

1. Records of plant performance and of public health furnish no evidence to support any increase in the stringency of the existing bacteriological standards.

2. A revised standard should not be based solely upon the capabilities of a few large modern plants without considering the vastly larger number of small plants which may be unable to comply.

3. Most water purification plants can comply with the existing bacteriological standard on the basis of plant effluent samples, but many plants will fail at times on the basis of distribution samples. If distribution samples are to be considered in a revised standard, compensating factors should be allowed based on the characteristics of the individual supply.

4. There is no justification for a return to the presumptive test as a basis for quality standards.

5. There appears to be no reason for the adoption of a larger standard sample.

6. A revised standard should give definite recommendations as to frequency of sampling and testing on a basis of size of plant, previous record and quality of raw water.

7. A revised standard should specify the period of time to be used in applying the standard. The shorter the time the more difficult will be the compliance.

8. A revised standard should emphasize the importance of cross-connections.

9. If possible, a revised standard should be based upon the results of scientific research rather than upon empirical considerations.

10. The section on chemical requirements is in need of minor revision.

### References

1. Typhoid Fever in Minneapolis and Gastro-Enteritis in Milwaukee. Committee Report. Jour. A. W. W. A., **31**: 374 (1939).
2. Streeter, H. W. Standards of Raw and Treated Water Quality. Jour. A. W. W. A., **31**: 1479 (1939).
3. Scott, Warren J. Bacteriological and Field Studies of Water Distribution Systems. J. N. E. W. W. A., **55**: 83 (1941).

## Water Purification Plants and Water Quality Standards

*By John R. Baylis*

The water purification plant operator should have some aim in view as to the quality of water to be produced by the purification plant. In order that this aim is not too low, there should be requirements for quality of the water, adequacy of treatment plant structures, capability of personnel in charge of the water system and and treatment plant, and adequacy of the system to guard against gross contamination of the supply before treatment and *any* contamination of the water in the distribution system. These requirements should be set by public health officials. A standard of quality for water served on common carriers engaged in interstate commerce has been in existence since 1914. Although this standard was prepared originally for the purpose stated, it soon became the guide for standards of quality adopted by the various state departments of health throughout the United States.

The bacteriological quality of the water was, in reality, the only requirement of the standard. Any water meeting the bacteriological requirement almost invariably was certified as being suitable for use on common carriers. This requirement was not very rigid, and was set so that practically all of the better class of municipal water supplies would have no difficulty in meeting the standard. The reduction in diseases commonly transmitted by water was, in 1914, so low in cities served by adequate treatment plants that no additional improvement seemed desirable.

The general reaction of the water purification operators was to be safe beyond question, so most of them gradually improved the bacteriological quality of the water in their plants to the extent that it was much better than the requirement. This brought about the belief by public health officials that the requirement should be made more rigid so as not to be so far behind practice. The standard was changed in 1925, with the bacteriological requirement being made more rigid but set so that all of the efficiently operated water filtration plants would have no difficulty in complying with the requirement. The writer recalls hearing much argument by a few against making the requirement more rigid because there was no evidence that water meeting the 1914 standard was not safe for drinking. Very few now believe the 1925 standard is too rigid.

The standard is again up for revision, with opinion divided on the extent to which it should be revised. Many believe that the incidence of diseases usually transmitted by water in cities and towns served with public supplies offers ample proof that adequate protection against the transmission of diseases by water is being given. Others believe that since such diseases have not been stamped out entirely still more rigid requirements should be imposed upon the water works. The writer belongs to the group who believe much would be gained by making the standard broader and by giving recognition in some manner to the production of water of a bacteriological quality much better than the present requirement. Also he believes that a standard in which the main requirement is based upon non-pathogenic bacteria is too limited to give the protection to the water consumers it should give. It is true that other qualities are mentioned in the present standard and still more are mentioned in the proposed revised standard, but almost no importance is now attached to the other recommended qualities. They are suggestions and not requirements.

With the exception of water containing some unusual mineral substance such as fluorine, there would be much resentment from the officials of a water works, in which the bacteriological results meet the present standard, if the water should be classified as unsafe because of other deficiencies of the system.

If every case of illness contracted from water could be determined beyond doubt, there would be something more specific upon which to base conclusions. Since such proof cannot be obtained, there is little hope of unanimity of opinion as to how pure the water should be bacteriologically. All that one may say at the present time is to state he believes there are a few cases of illness caused from drinking the water in some of our cities where the public supply averages well within the requirements of the U. S. Public Health Service standard.

### Result of Further Bacterial Reduction

A 99.5 per cent reduction in coliform organisms in water may produce a reduction in water-transmitted diseases probably close to the same percentage reduction. This reduction in coliform organisms would be sufficient to enable many waters used for public supplies to pass the present bacteriological requirement. Naturally it is now impossible to predict the amount of illness which would be caused by the cessation of all purification of water. Very likely it would be a figure in which we would say that 99.5 per cent reduction is not sufficient, even in those cities where the water is contaminated only to the extent that the 99.5 per cent reduction mentioned would cause it to comply with the standard.

This brings us to the value of a human life, and to the cost of illness. Where should we stop in expending money to prevent the spread of diseases? There was a great return at first on money expended for purifying water in the reduction of diseases usually transmitted by water. The introduction of chlorine for sterilizing water reduced further the cost of preventing the transmission of diseases by water. As the number of cases of illness and deaths were reduced to lower figures, the cost per case prevented probably has increased. Years ago the major advantage assigned to constructing a water purification plant was improved health. Since we have become accustomed to clear and palatable water, nearly all the cost of purification other than chlorination and ammoniation can be assigned to improving other than the bacteriological qualities of water. There are not so many water supplies where more than $2.00 per million gallons should

be assigned as the cost of treating the water for killing or removing the bacteria. The average is less than $1.50. In cities of moderate size, and larger, with a per capita consumption of 150 gallons daily, the annual per capita cost for sterilization is only about 10 to 15 cents.

Assume in a city of 100,000 inhabitants with no treatment of the water that there would result about 1,000 cases of illness annually varying from minor to serious illness, and 100 deaths. Further assume by sterilization with chlorine costing $15,000 annually that the cases of illness are reduced to 5 and the deaths to 0.5 annually. Although the figures are assumed, they are within the bounds of expectation for some cities. With a human life valued at $50,000, and a case of illness at $500, the annual saving would be about five and one-half million dollars for the $15,000 expenditure. There of course are some who will not agree that so many cases of illness and deaths would occur, that a human life is worth $50,000, and that the average illness does $500 damage to a person.

Would you sell your life for $100,000? Would you purposely contract a case of typhoid fever for $5,000, or purposely contract a case of ordinary dysentery for $100? There are not many who would be glad to see a relative die when they are the beneficiary of a $50,000 insurance policy. Is this not the better way of fixing the value of a human life than to use the value which might be fixed by the court, or the officials of a company settling for an accidental death? Money paid to the members of a family for a death should not be regarded as the value of that life, even though the amount paid is a large sum. The writer believes it would be money well invested in this assumed city to reduce water-borne diseases to about one person annually and the death rate to one person about every 10 years or even less frequently. There is the possibility that this could be done in the assumed city with an additional expenditure, probably of less than $10,000 annually.

### Use of a Grading System

In May, 1940, the writer presented a paper before the Illinois Section of the American Water Works Association on "Water Quality Standards" (Jour. A.W.W.A., **32**: 1753 (1940)). The need for more rigid requirements for the construction and operation of water works systems and treatment plants was stressed. A system of grading was advocated. The bacteriological requirements for Grade D water as given in the article would be water just passing the 1925 standard of

the U. S. Public Health Service. For the water to be classified as Grade A, the number of coliform organisms should average not more than one-twentieth the number allowed by the 1925 standard. For Grade B water, the coliform organisms should average not more than one-tenth the present standard. The oral discussions of the paper at the time of its presentation were favorable. Since presentation of the paper, the writer has had the opportunity of discussing the recommendations with a number of water treatment plant operators. Reactions to the article appear to be about as follows:

There are about 25 per cent of the water purification plant operators who believe the bacteriological requirement as set forth for Grade A water cannot be met with a reasonable cost of purification.

About 50 per cent of the operators state that they are producing water equal to or approximately equal to Grade A water, particularly for the completed coliform organism test.

The other 25 per cent say they would have no difficulty in producing Grade A water with an increase in sterilization cost but see no reason for so doing as the water is better than the requirement of the U. S. Public Health Service.

Nearly all the water of public supplies now complies with, or could easily be made to comply with, the suggested bacteriological requirement of the completed test for Grade B water as given in the article.

The majority of the water purification plant operators doubt the wisdom of giving consideration to presumptive tests.

The majority would have no objection to a system of grading the water.

About 90 per cent of the operators believe that the water should be much better than the bacteriological requirement of the present U.S. Public Health Service standard, and that they have no desire to reduce the sterilization treatment now being given the water in their plants.

In giving approximate percentages, the figures are not intended to be exact, for no record has been kept of the views of those interviewed.

### The Public Health Viewpoint

The most discouraging remarks have come from public health officials. Where most encouragement was expected, there has been the least. Perhaps some of them are having so much trouble trying to force a few water works to comply with the present standard that

they do not wish to increase their troubles. Perhaps others are so elated over the enormous reduction already made in diseases usually transmitted by water they have lost sight of the fact that still better results likely could be obtained at a moderate increase in the cost of treatment. The writer hopes he has heard mainly from those opposing a more rigid standard. Regardless of the reasons, there is much opposition on the part of public health officials to making water quality standards more rigid. With such outspoken opposition it leaves the water purification plant operators puzzled as to what to do.

Bearing in mind that the bacteriological quality of water supplied the consumers in many cities with well operated water purification plants is now very much better than the requirement of the U. S. Public Health Service, it is believed the water purification plant operators are justified in asking public health officials the following questions:

If a water treatment plant is producing water which complies bacteriologically with Grade A water as defined in the article referred to above, would you recommend a reduction in the treatment to produce a poorer quality of water?

If you were employed to operate a water purification plant, would you try to produce water just passing the standard of the U. S. Public Health Service, or would you try to produce water of higher quality?

If you would strive to produce water better than the standard, it would be helpful to the water purification plant operators to know approximately the bacteriological quality you would try to produce.

If you favor the production of a higher quality of water where it can be done at a reasonable cost, why do you not favor wording the standard in a manner to give some recognition and more encouragement to those water purification plant employees who are striving to maintain a high standard of quality?

As stated, the operators should have some aim in view, and it is believed everyone concedes that the aim should be better than the standard. Although the standard is something never to fall below, and it is necessary to average better so as never to exceed, we are in doubt as to how much better the aim should be.

The water purification plant operator receives more discouragement than encouragement from the "Drinking Water Standards" of the U. S. Public Health Service. To illustrate, the report of the Advisory Committee on Official Water Standards in 1925 states that it was to formulate definite specifications which may be used by the Public

Health Service in the administrative action which it is required to take upon the supplies of drinking water offered by common carriers for passengers carried in interstate traffic, and the recommendations apply only to this special case and are not proposed for more general application. Knowing that the standard would be the guide for requirements of all of the states, they still inserted the statement that the recommendations were not proposed for "more general application." Furthermore there is not great encouragement in using the standard as a guide for treatment plant operation when the report says, "Thus, to state that a water supply is 'safe' does not necessarily signify that absolutely no risk is ever incurred in drinking it." To offer further evidence of discouragement by the standard, it states that the turbidity of the water should not exceed 10, and in general it should be not more than 5. Do public health officials expect filtration plants to supply water with a turbidity of 3 or 4, or do they expect it to be 0.1 to 0.4 as is now being produced by most of the filtration plants? The two main tests of the efficiency of a water purification plant are turbidity reduction and bacteria reduction. We hope the bacteriological requirement of the standard can be regarded more exacting than the suggested turbidity limits, otherwise we would not have so much faith in the standard.

### Inadequacy of Proposed Revision

The proposed revisions of the standard are good, with minor exceptions, and are in the right direction, but they are not extensive enough to accomplish all that should be accomplished. Perhaps this is all that can be done at the present time without serious opposition. Much of the opposition from water purification plant operators to extensive revision likely would be of the nature that they prefer to have a standard so low they need never worry about the possibility of not meeting the suggested requirements. If the requirements are set with this in view, then the writer urges the operators of water purification plants to set their own aim of quality and forget about the U. S. Public Health Service and state health department standards as guides to efficient operation.

Many of us would like to see a standard which could be used as a guide to operation and not one so far behind practice that it is of little value. If all public health standards were abolished, nearly all of the water purification plant operators would continue to maintain the high quality of water now being maintained, because they realize the

responsibility of their positions in avoiding the spread of water-transmitted diseases. The fact that the water treatment plant operators are doing such a good job without force may be reason why public health officials are slow in recommending more rigid requirements. They point to the fact that there is no need for further improvement in the incidence of water-borne diseases. Do they attribute present conditions to water just passing the bacteriological requirement, when it is known that nearly all the water of public supplies is far better than the requirement nearly all of the time? Do they believe the present standard is influencing most of the water purification plant operators in their effort to produce water of the highest quality possible?

The minor revisions which have been recommended are encouraging, but likely will accomplish very little in giving additional safeguard to health. Much more could be accomplished by giving us a good aim of performance in the bacteriological quality of water, and being still more specific in defining adequate water systems, capable personnel, and good operating performance. This would produce no unjust burden upon any one or any treatment plant.

EDITOR'S NOTE: *Discussions on the subject of revising the federal standard are invited. Please send them to A. W. W. A. headquarters before November 10, so they may be published in December.*

# ABSTRACTS OF WATER WORKS LITERATURE

**Key. 31:** 481 (Mar. '39) indicates volume 31, page 481, issue dated March 1939. If the publication is paged by issues, **31:** 3: 481, (Mar. '39) indicates volume 31, number 3, page 481. Initials following an abstract indicate reproduction, by permission, from periodicals as follows: *B. H.—Bulletin of Hygiene* (*British*); *C. A.—Chemical Abstracts; P. H. E. A.—Public Health Engineering Abstracts;* *W. P. R.—Water Pollution Research* (*British*); *I. M.—Institute of Metals* (*British*).

## FILTRATION

**Straining of Water and Sewage.** P. L. Boucher. The Engr. (Br.) **171:** 322 (May 18, '41). In practical applications of straining plant, 3 degrees of straining—coarse, medium, and fine—may be defined. Coarsest used in pump suction wells such strains may be of rack construction with bars at perhaps 3″ pitch. Medium straining defined as use of woven wirecloth having from 4 to 40 meshes per in. Material used on removable strainers for water works screening wells, on automatic screening plant, and in enclosed strainers for water mains. Fine straining defined as use of woven wire cloth having apertures less than $\frac{1}{64}$″. Various degrees of fineness down to cloth having about 350 meshes per in. with apertures of about 40 $\mu$, available. Fine straining on large scale comparatively new development in water treatment. Modern, automatic, self-cleaning straining plant has made possible practical utilization of finest weave of wire cloth, with results which approximate mechanical filtering action of sand beds. Great advantage of straining plant over filtration plant is exceedingly high capacity, as illustrated by following tabulation, giving filtering speeds in vertical ft. per hr.:

| | |
|---|---|
| slow sand filters | 0.33 |
| rapid filters | 19-38 |
| 350-mesh wirecloth | 540 |
| 200-mesh wirecloth | 640 |
| 100-mesh wirecloth | 570 |
| 40-mesh wirecloth | 720 |

Exptl. work has shown that chemically coagulated water may be successfully clarified by fine straining. Copper, brass, phosphor-bronze, Monel metal, and stainless steel are all metals available for wire cloth. When finer meshes in use, corrosion possibilities have to be studied. Tendency of wire cloth to suffer from corrosion directly proportional to its mesh in wires per in. Ability to resist corrosion diminishes as square of wire sizes. In recent tests made on River Irvine water, particles of suspended matter caught on wirecloth are of such sizes that, although practically invisible in original sample, they are capable of being strained out by fine-mesh cloth. For certain classes of water, originally bacteriologically safe, and for many industrial water supplies, fine screening all that is required.—*H. E. Babbitt.*

**Research and Control.** Norman J. Howard. Can. Engr.—Wtr. & Sew. **79:** 5: 11 (May '41). Most difficulties met with in operation of rapid sand filters are due to use of incorrect size of sand, imperfect conditioning of applied water or faulty washing. Sand used in no. of modern plants has effective size of 0.55 mm. and some authorities have suggested effective size in excess of 0.8 mm. Modern practice in filter washing includes employment of rate to give 50% sand expansion, combined use of air and water, and surface washing in conjunction with usual backwashing. Early re-

searches of Baylis created interest in surface washing. Later, sub-surface filtering and washing system developed by Ira Jewell. More recently, Palmer filter sweep or agitator, in which high-pressure jets from nozzles on revolving arms used to cleanse sand during backwashing, used. More than **700** units of latter type now in operation. Much progress made and many operating problems eliminated by recent advances in art of water treatment.—*R. E. Thompson.*

**Acceleration of the Filtration Process and Its Effect on the Quality of Water.** P. V. MOZZHUKHIN AND L. N. SHUSTOVA. Vodos. Sanit. Tekh. (U.S.S.R.) **3:** 47 ('39); Khim. Referat. Zhur. (U.S.S.R.) **7:** 92 ('39). Increase of velocity of filtration from 5 to 8–9.5 m./hr. did not appreciably affect physical-chem. or bacteriol. properties of filtrate. Increase of velocity of filtration lowered total cost.—*C. A.*

**The Three Jewells—Pioneers in Mechanical Filtration.** M. N. BAKER. Eng. News-Rec. **126:** 179 (Jan. 30, '41). Brief account of early activities of Omar H. Jewell and his two sons, Ira H. and William, in development of mechanical filters. Both sons died in '40. Senior Jewell's original interest in filtration was due to desire to improve quality of boiler feed water taken from Chicago R. for grain elevators. Of scores of filtration patents taken out by Jewell trio, first 10 were granted to Omar in 1888–90. Patent of July 15, 1888, was for combination filter and chlorine gas generator. Latter consisted of electrodes placed in dome of filter tank. First Jewell filters for munic. supply were placed in commission at Rock Island, Ill., in Apr., 1891, and within 5 yr. Jewell filters were in use in 20 American cities. Impetus was given to adoption of mechanical filters by tests at Providence in 1893–4 and at Louisville in 1895–6. Earlier and almost unknown demonstration test at Brockton, Mass., in 1888, would have resulted in an adoption had it not been thwarted by "advice" of Mass. State Board of Health, which had strong aversion to use of alum as coagulant.—*R. E. Thompson.*

**Current Trends in Water Filtration Practice in Canada.** A. E. BERRY. Can. Engr.—Wtr. & Sew. **79:** 4: 7 (Apr. '41). Nearly 1,300 water works systems in Canada and 130 municipal filter plants. Of latter, 12 are slow sand plants, 47 pressure mechanical and 71 gravity mechanical (including 1 drifting sand). No tendency to install slow sand filters in recent yr. Earlier attempts to secure clean water involved use of infiltration basins. Most of pressure filters of horizontal type, 8′ diam, being popular size. Many of plants installed without provision for pre-treatment and this has been distinct handicap. In spite of inherent deficiencies, no. of these plants have given long service. On whole, however, pressure filter cannot be regarded as nearly as satisfactory as gravity unit unless adequately equipped and given proper attention. Quebec Ministry of Health will not approve pressure units for municipal purposes. Larger, recently constructed gravity plants listed. Alum used almost exclusively as coagulant, gravimetric feeders now taking precedence over volumetric equipment, particularly for larger amts. of chemicals. Mixing effected by either spiral flow tanks or mechanical agitators, mixing periods of 30 min. or more usually provided. Tendency to increase retention in settling basins to 3–4 hr. Settling basins 20–30′ deep not uncommon. Filter sand usually of 0.4 mm. effective size and 1.6 uniformity coef., although trend toward use of coarser sand, up to 0.6 mm. effective size. Anthracite used as filter medium in 1 plant. Gravel up to 1.5–2.5″ in size usually employed, depth approx. 15″. 18″ used in some plants. Grouting of gravel not practiced in recent yr. Underdrain laterals usually of cast iron, spacing ranging from 6″ to 12″. Spacing orifices generally about 6″, although in some recent plants increased to 12″, with correspondingly larger openings. In recent plants, bronze orifices employed almost entirely. Wheeler filter bottoms incorporated in few plants. Washing rates moderate—20–30″ vertical rise per min. Air not used extensively in washing, except in Quebec. Spacing of wash troughs approx. 6′, although spacing is

8′ in some instances. Height above sand usually 2′ or more. Amt. wash water used less than 5% of output in most cases, but ranges up to 10–15% in some plants. Rate controllers almost universally employed. Per capita cost of gravity filter plants ranges from \$2.31 to \$43.10 and averages \$11.35. Ave. cost per mil.gal. of designed capac., \$67,965, min. being \$23,800 and max. \$224,000. On basis of sand area, cost varies from \$4.72 to \$512.00 and averages \$159.20 per sq.ft. In general, can be said that all surface water supplies require filtration. No. of filter plants in Canada small compared with no. of surface waters employed and filtration should be more widely practiced.—*R. E. Thompson.*

**Toronto Island Filtration Plants, Drifting and Slow Sand Filters.** Norman J. Howard. Can. Engr. Wtr. & Sew. **79**: 6:35 (June '41). Toronto always secured water supply from Lake Ontario but prior to '10, supply unfiltered. In '10, as result of typhoid epidemic, chlorination adopted and consideration given to construction of filter plant. Slow sand plant completed in '12 but within 6 mo. demand exceeded capac. and mixture of chlorinated raw and filtered water had to be resorted to until drifting sand plant completed in '17. Latter plant capac. 60 m.g.d. (Imp.) and rate of filtration 150 m.g.a.d. (Imp.). 10 circular steel filters, 14′ high and 50′ in diam., each divided into 30 units. Filter layer consists of 3 grades of rounded gravel to depth of 10″ and 9′ of sand with effective size of 0.45 mm. Drifting sand principle, by which sand drawn through extractor pipes around perimeter of each unit, washed and returned to filter with incoming raw water, causes sand to resolve itself into 2 sections—stationary sand body and drifting sand body. Large proportion of impurities removed by drifting sand and carried out of filter by it, while stationary layer retains remaining impurities. No sedimentation basin employed. Plant in successful operation for over 20 yr., and rates up to 175 m.g.a.d. (Imp.) employed during high-demand warm-weather period—*R. E. Thompson.*

**Refilling of Slow Sand Filters by Hydraulic Transportation of the Sand.** Warner Duhnsen. Gas. u. Wasser. (Ger.) **83**: 527, Oct. 19, '40). No mechanical method as yet developed for removal of dirty upper layer of sand in slow sand filters. After removal of several top layers, cleaned sand has to be refilled. For this process new mechanical process is described. Washed sand is lifted by belt conveyor to screen where large particles, occasionally present, are removed. Then mixed with from 7 to 11 parts water. Mixture flows by gravity into special pump with easily changeable armor and sent through 4″ spiral-reinforced rubber tubes to top openings of filter to be filled. Nozzle bent horizontally to splash stream against walls and cause uniform distr. Little manual labor required to spread sand to even surface if deposited on dry surface. As flushed-in sand is deposited somewhat tightly, it is spaded to depth of 10″. Resistance of filters refilled with mechanical process increases more slowly than that of filters refilled by hand labor. Cost of mechanical filling of filter unit about 25% less than that of filling by hand and requires only 5 laborers compared to 12 in older method.—*Max Suter.*

**The Effect of Filtration of Dissolved Salts in Sand Filtration.** Zinnosuke Tyo. Mitt. Med. Akad. Kioto. (Jap.) **29**: 597 (*in German*) ('40). Aq. solns. of $FeCl_3$, $PbCl_2$, $NiCl_2$, $MnCl_2$, $CuCl_2$, $CaCl_2$, $BaCl_2$, $MgCl_2$, NaCl or KCl, at concns. of 100 mg. per liter filtered under the same exptl. conditions through sand layer 100 cm. deep. Decrease in concn. of the ions studied in each 20 cm. of sand layer. Intensity of filtration of salts with regard to cations decreased in order: Fe, Ba, Mn, Pb, K, Ca, Mg, Ni, Cu, Na. Extent of filtration at different depths varied with type of salt; i.e., Fe, Ba, Pb and Mn more or less readily retained in upper sand layer, while Ca relatively markedly retained only in lowest sand layer. Extent of filtration of Cu, Mg, Ni and Na through entire sand layer for most part followed straight line. In spite of marked decrease in cations during sand filtration, corresponding Cl con-

tent did not diminish appreciably. Cations especially strongly adsorbed by finest grains of sand. Presumably, salt in sand layer quickly undergoes ionic exchange and only cations adsorbed by sand. Observation of 10 different cations in slow sand filter reveals characteristic filtration curve for each. Sand filter itself not merely support for biol. filter film, but also functions as very active filtration mechanism. Cl content of city tap water averaged 5.61 mg. per liter. Upon filtration through 100-cm. sand layer, increased by 3.3%. If 0.1% $Fe(NO_3)_2$ or $Cu(NO_3)_2$ filtered through 100-cm. sand layer, nitrate concn. did not change appreciably. In general, anions only slightly retained by sand filter.—*C. A.*

**Investigations on the Reduction of Bacteria and on Chemical Changes in the Sand Filters of Water Works.** K. STUNDL. Z. Hyg. InfektKr. (Ger.) **122:** 1 ('39). Discusses effect of protozoa in removal of bacteria from water in sand filters. Protozoa most abundant in film over surface, but removal of bacteria occurs in filter itself, even in layers where no protozoa are found. Chem. comp. of water also changes during filtration. Dissolved iron oxidized and iron hydroxide deposited in upper layers of sand. Ammonia and nitrite oxidized to nitrate. Chem. changes occur more rapidly in surface film than in filter itself, probably owing to greater no. of bacteria and to higher oxygen content. Chem. changes in deeper layers increase after filter has been in operation for some time.—*W. P. R.*

**Trickling Filter Design, Construction and Operation.** Public Wks. **71:** 23 (Mar. '40). Underdrainage of trickling filters should provide for good hydraulics of max. and min. flows, as well as adequate ventilation space to permit free passage of air from underdrains up through filter. Underdrainage openings should approximate 20% of floor space. Disadvantages of old methods and practicability of new "block type" underdrainage clearly outlined, with list of manufacturers and applications of commercial products. Hydraulics of drainage channels, "block type" covers for drainage channels, and ventilation requirements comprehensively explained. Filter piping may be provided with freeze protection by laying above floor and providing drain or "bleeder" outlets. Provisions for fly control by flooding discussed. Secondary settling mandatory for good trickling-filter results. Results of no. of trickling-filter and settling units for ave. influent B.O.D. of 303 p.p.m., 84.2% removal. Relative stability ratings varied. Dissolved oxygen averaged 4.3 p.p.m. Article concise treatment of new developments in trickling-filter design.—*P. H. E. A.*

**Soil Filtration as a Method for the Treatment of Phenol Waste Waters.** A. I. ZHUKOV. Vodos. Sanit. Tekh. (U.S.S.R.) No. 4-5: 83 ('39); Khim. Ref. Zh. (U.S.S.R.) No. 9: 80 ('39). Describes results of expts. of 2 yr. duration on disposal of phenolic waste waters from gas works. Possible to purify these waters by soil filtration either with other waste waters containing phenol, or after dilution with pure water. In first case satisfactory results obtained with concs. of phenol up to 150 mg. per liter, and with daily application to filter area of 50 cu.m. per ha. of waste waters. In second case, wastes containing up to 250 mg. per liter with same daily vol. of flow, satisfactorily purified. With greater vols. and concs. of phenols, phenol not completely destroyed by filtration. No fatigue of filtration areas observed.—*C. A.*

**Filter Operation and Maintenance.** JOHN R. BAYLIS. J.N.E.W.W.A. **54:** 393 (Dec. '40). Operation and maintenance of filters in treatment and filtration plant important part of duties in running of plant. Operating methods vary widely. Author states it is far better to have less sand-grain coating and cleaner filters than to have well coated sand and filter units filled with mud balls and clogged areas. Duties of operators detailed with discussion of reasons for recommendations. Tendency of past few years to speed up filtration rate and to use coarser

sand has, in some instances, resulted in too close an approach to limit of rate and size of material to insure excellent results under all conditions of quality of applied water. Operators not always responsible for condition of filters; management should provide equipment necessary for proper maintenance. Effective size of the finest filter sand that should be used for water that produces weak coagulation is about 0.35 mm. For ave. water, an effective size of about 0.50 mm. probably about as coarse as should be used. With some waters even coarser sand will produce satisfactory results. Improved method of measuring filter efficiency consists of running 100 to 150 ml. per min. of effluent of filters, at constant rate, through 1-gram plugs of absorbent cotton for period of such length as indicated best by experience. Plugs then burned and ash weighed. Amt. of ash that should be present in filtered water not as yet known; indications are that value should not be more than about 0.025 p.p.m. Objection to method is that filters of one plant not directly comparable to those of another; useful, however, in comparing units in same plant.—*Martin E. Flentje.*

**Scrubber System in Filters—Discussion.** A. V. Foltz. Ohio Conf. W. Purif. 20th Ann. Rept. ('40) p. 106. 4 rapid sand filters at Findlay, Ohio, softening plant, each of 1-m.g.d. capac. at rate of 125 m.g.d. per acre, equipped with high-pressure scrubbers 2″ above sand surface. Ten $1\frac{1}{2}''$ laterals, spaced 24″ apart, have 2 rows of $\frac{3}{16}''$ holes on 9″ centers, located on lower side 120° apart. Scrubber valve opened 1 min. before backwash valve and remains open approx. 3 min. Approx. 22% of wash water passes through scrubber system. Total wash period is 4.5–5 min. In 9 yr. incrustation of sand amounted to 38%. Filters free of hard spots and runs average about 56 hr. *Ibid.* p. 106. John Britton. Filters at Avon Lake in operation 13 yr. Trouble being experienced due to mud balls. During past 10 mo. Palmer surface washer used in all 4 filters intermittently and mud balls and hard spots eliminated. Less wash water now required. *Ibid.* p. 107. C. P. Hoover: Pointed out that as agitator is below water surface there is direct connection between dirty water in filter and high pressure line. Sudden drop in pressure in latter would allow dirty water to enter. *Ibid.* p. 107. C. E. Palmer: Use of agitator renders high wash rates unnecessary. If sand expanded until completely fluid, agitator will circulate sand so that all of it is subjected to cleaning action of high velocity jets. 20% expansion sufficient under most conditions. Backwash rate of 10–12 gal. per sq.ft. per min. recommended for use in conjunction with agitator. *Ibid.* p. 108. H. G. Turner: 50% sand expansion should be employed at some stage of wash to facilitate removal of material broken up by agitators.—*R. E. Thompson.*

**A Discussion of Filter Washing Theory.** Edward R. Stapley. Southwest W. W. Jour. **22:** 6: 13 ('40). Article is a clear exposition of factors involved in, and derivation of, formulas of Hulbert and Herring, and of Fair and Hatch, using a mixture of Plumb Island and Ipswich sands with effective size of 0.27 mm. and a uniformity coefficient of 1.40. Experimentally obtained values checked closely with values calculated by above formulas. Graph given shows variation of wash water rise and temperatures at expansions of 20% to 80%.—*O. M. Smith.*

**Warsaw's Water Plant Destroyed.** Anon. Eng. News-Rec. **126:** 943 (June 19, '41). Brief data given concerning water filtration plant of Warsaw, reported by Stephen de Ropp to have been destroyed during "blitzkrieg" of '39. Plant consisted of 16 mechanical filters and had normal rated capac. of 72 m.g.d. (U.S.). Filters supplied from existing settling basin, ultimately to be converted into coagulation basin, and mechanical filter effluent delivered to either existing slow sand filters or settling basin. When completed in '33, was largest rapid sand filter plant in Europe. In '37, water supply apparently filtered through both plants and chlorinated. Pop. then 1,200,000. At time, about 170 water works in Poland and about 40 under construction, mostly supplying

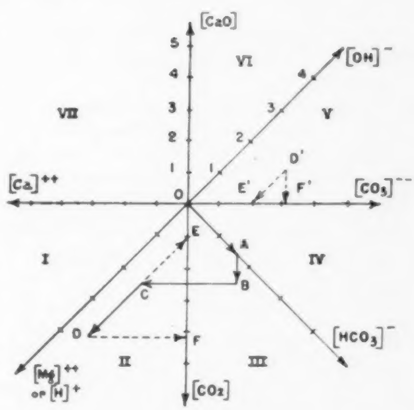
ground water. Iron removal by aeration and filtration practiced at about 45 plants.—*R. E. Thompson.*

**Lindsay Overcomes Erratic Filter Operation by Installation of Rate-of-Flow Controllers.** W. S. Mills. Can. Engr.—Wtr. & Sew. **79:** 3: 18 (Mar. '41). Variations in rate of filtration due to changing head losses across 5 pressure filters in Lindsay, Ont., led to erratic results. To correct condition "Foxboro" flow controllers recently installed. Installation consists of 5 air-operated throttling valves, one on each influent line, and 5 controllers. Latter are essentially recording flow meters into which are built sensitive, throttling-type, air pressure controls. Any variation in flow through filter produces equivalent change, through controller, in air pressure on valve diaphragm and consequently in valve position. Installation believed to be first of kind in Canada. —*R. E. Thompson.*

**The Filtration System for the New M.I.T. Swimming Pool—Design and Operation.** Thomas R. Camp. J. Boston Soc. of Civ. Engrs. **28:** 54 (Jan. '41). Details of design and features of operation of M.I.T. pool presented. In circulation system, water coagulated with alum and soda ash, filtered in pressure tanks, and disinfected by continuous chlorination. Special features include large coagulation tank (detention period 1 hr.), use of ammonia to prevent tastes and odors from chlorination, long recirculation period (12 hr.), continuous coagulation, a photo-electric counter, low pumping head, and use of sodium thiosulfate in foot baths.—*P. H. E. A.*

## SOFTENING AND IRON REMOVAL

**Graphical Calculation of Softening Conditions of Water.** J. W. Arbatsky. Gas. u. Wasserfach. (Ger.) **83:** 90, 116 (Feb. 24, Mar. 9, '40). Analysis of softened water expressed in equivalent concentrations of free carbon dioxide, bicarbonate, carbonate, hydroxyl, calcium and magnesium represented on diagram (see fig.) as single point. Location of point indicates whether water has been under- or over-treated with either or both lime and soda ash, and also corrective dosages of acid, caustic soda, or other chemical required to effect more perfect softening. Diagram consists of 7 vectors representing 8 variable constituents arranged or selected such that incompatible constituents are scaled off in opposite directions. To locate point representing particular water, equivalent concentrations of constituents present are scaled off additively, from origin *O*, each in proper direction parallel to its vector axis. Example is point *D* in fig. Obtained by scaling bicarbonate content *OA*, free carbon dioxide *AB*, calcium *BC*, magnesium *CD*. In example, Point *D* falls in Sector II and apparent that water requires, for corrective treatment, soda ash in amount *DF* and lime in the amount




*FO*. Alternative treatment yielding same result would consist of caustic soda in amount *DE* and lime in amount *OE*. Similarly a water, whether softened or unsoftened, represented by point falling in any other sector characterized in terms of its deficiencies or excesses. Thus if point falls in Sectors I or II, water is deficient in both lime and soda ash; in Sectors III or IV, deficient in lime and excessive in soda ash; in Sectors

V or VI, excessive in both lime and soda ash; in Sector VII, excess in lime and deficient in soda ash. If, for example, point for softened water falls at $D'$ in Sector V, excess of lime is indicated by $D'F'$, excess of soda ash by $OF'$. Dosages should be altered accordingly or, if it is desired to supply corrective treatment, strong acid or magnesium salt in amount $D'E'$, together with calcium salt in amount $OE'$ can be used. Alternative treatment would consist of carbonic acid equal to $D'F'$ and calcium salt equal to $OF'$. Perfect softening indicated (within limits of process) when point falls at origin $O$. Author compares method with one proposed in '35 by Staffeldt (*see* Chem. Abstracts **29**: 7534). [Method ingenious and valuable because it enables representation of errors of treatment graphically by single point, but, having all of analytical data expressed in equivalent concentrations, computations for corrective treatment are perhaps more readily made by simple arithmetic.]—*W. F. Langelier.*

**Effect of Temperature Increases on Softening Reactions in Samples Mixed in Laboratory.** P. J. O'Connor. Ohio Conf. W. Purif. 20th Ann. Rept. ('40) p. 73. Lime-soda softening employed at Warren, Ohio, since June '38, hardness of delivered water being about 85 p.p.m. Hardness of raw Mahoning R. water varied from 33 to 236 p.p.m. during '39. Observed that softening reactions proceed much more slowly and that much more calcium carbonate removed by filters at low temps. Observation confirmed in lab. by treating duplicate samples and maintaining one at low temp. by immersion in ice bath. Alkalinity of samples maintained at low temp. corresponded to those obtained in plant operation, whereas alkalinity of samples subjected to same treatment except that temp. was allowed to increase on standing in lab. had alkalinities about 40 p.p.m. lower. Even after settlement periods of 18 hr., considerable difference in alkalinities of 2 series of samples. Evident that lab. expts. will not duplicate plant results unless temp. of samples controlled—*R. E. Thompson.*

**Recent Developments in Water Softening.** H. L. Thackwell. Tex. W. W. Short School. **22**: 33 ('40). Main improvements in zeolite process is perfection of zeolites with higher exchange rates. New form of base exchange, carbonaceous zeolite, will remove sodium, calcium and magnesium, exchanging hydrogen ions in their places, thus forming carbonic, sulfuric and hydrochloric acids. With adequate aeration, carbonic acid removed, thus completely removing all bicarbonates and carbonates and lowering total solids. Carbonaceous zeolite regenerated with sulfuric acid. By adjusting cycle and amount of regenerating acid, selective exchange can be accomplished by securing conversion of all bicarbonates and carbonates of calcium, magnesium, and sodium without converting any of sulfates and chlorides resulting in complete removal of alkalinity. If water is aerated and passed through ordinary zeolite softener, water with zero hardness, and only sulfate and chloride, produced.—*O. M. Smith.*

**Softening Agents, With Special Attention to the Polyphosphates.** August Chwala and Aldo Martina. Melliand Textilber. (Ger.) **21**: 285, 464, 526 ('40). Alkali metal polyphosphates contain one or more un-ionized Na atoms in the anion. Can be replaced by $Ca^{++}$ of hard water, thus rendering it soft. $Ca^{++}$ so completely removed that its concn. is less than soly. product of Ca soaps. Calgon mainly $(NaPO_3)_6$, 4 of Na atoms being in anion complex. Higher polyphosphates are made by melting $NaPO_3$ and $Na_4P_2O_7$ together in various proportions and quenching. Efficacy as softeners can be correlated with their "Ca value" (CaV)—wt. of Ca in grams which 1 gram of substance can effectively bind in the anion; detd. by nephelometric titration. CaV depends on concn., on ration of $Na_2O:P_2O_5$ and on quenching temp. of melt. Melt of $5Na_2O:3P_2O_5$ shows max. CaV when quenched at 860°. Values of CaV obtained exptly. vary with end pH of titration. Shapes of curves showing relationship vary greatly with compn.

and quenching history of polyphosphate. $(NaPO_3)_6$ shows sharply rising CaV at end pH of over 8. $5Na_2O \cdot 3P_2O_5$ shows lowest rise in CaV with rising end pH. CaV of all samples diminishes with increasing temp. of titration. Ca soap solvent power (CaSP) is detd. by adding polyphosphate to standard Ca soap suspension until it becomes clear. CaSP varies with temp of titration. $(NaPO_3)_6$ shows fairly flat curve for CaSP *vs.* temp. $Na_5P_3O_{10}$ shows steep curve, and actually shows greater value of CaSP than $(NaPO_3)_6$ at 85° and end pH of 8.5. All polyphosphates tend to hydrolyze in aq. solns., forming orthophosphates. Hydrolysis can be followed by diminishing value of CaSP after prolonged heating. $Na_5P_3O_{10}$ hydrolyzes less than $(NaPO_3)_6$. Practical washing tests on raw wool and artificially oiled cotton show that CaSP is much better index of practical value than CaV. In tests $Na_5P_3O_{10}$ fully as efficient as $(NaPO_3)_6$, and lower proportion of $P_2O_5$ more economical.—*C. A.*

**Water Softening in Relation to Soap Saving.** L. H. LOUWE KOOIJAMS. Water (Neth.) **24:** 206 (Dec. 13, '40). Experiments with "Neo-Permutit," synthetic silicate zeolite, and "Dusarit," carbon zeolite; glass filters with rough walls (produced by layer of paint covered with fine sand) to prevent short circuiting. Zeolites placed on layers of sand; 1,600 grams Neo-permutit and 900 grams Dusarit; filter thickness about 4" and 4.5", resp. Raw water total hardness 214–267 p.p.m., $HCO_3^-$ 160–180 p.p.m., $CO_2$ 2–4 p.p.m., Fe none. Exchange capacity of Neo-permutit relatively low as indicated by CaO adsorption per liter permutit at rate of 100 ml.: 3.5, 3.5, 2.9, etc. and correspond to values given by mfr. Dusarit-exchange capac. higher:

| *Rate ml./min.* | *Grams CaO/liter Dusarit* |
|---|---|
| 100 | 13.4 |
| 200 | 13.7 |
| 400 | 12.6 |
| 800 | 4.6 |

Softened water mostly restricted for washing, cooking and beverages. Unfit for drinking purposes, because Ca and Mg compounds changed to Na compounds and in Netherlands mostly temporary hardness, so that Na-bicarbonates are produced, giving taste.—*Willem Rudolfs.*

**Water Softening and Soap Saving.** T. FOLPERS. Water (Neth.) **25:** 46 (Mar. 21, '41). Effect of softened water on lead piping tested with old lead pipe covered with protective layer:

| WATER | CONTACT TIME | pH | $CO_2$ | $HCO_3$ | Pb | $O_2$ |
|---|---|---|---|---|---|---|
| | *hr.* | | *p.p.m.* | *p.p.m.* | *p.p.m.* | *p.p.m.* |
| Running | | 8.00 | 2.1 | 156 | 0.0 | 8.6 |
| Return | 18 | 8.78 | 0.0 | 162 | 1.32 | 6.3 |
| Running | | 8.19 | 0.0 | 162 | 0.0 | 4.0 |
| Return | 18 | 8.52 | 0.0 | 171 | 1.28 | 3.8 |
| Running | | 8.10 | 0.8 | 175 | 0.0 | 7.8 |
| Return | 18 | 8.38 | 0.0 | 180 | 1.54 | 5.4 |

Lead piping with protective layer allows soln. of lead above limit when softened water passes. Softened water from "Dusarit" filter has higher pH values, but makes lead carbonate soluble. Softening by Dusarit filter saves soap, is good for lab., steambaths, etc.—*Willem Rudolfs.*

**Consumption of Salt Cut One Third.** C. C. HARRINGTON. Power Plant Eng. **45:** 2: 61 (Feb. '41). Zeolite softening plant using 2,400 lb. salt per day reduced salt consumption to 1,600 lb. per day by installing brine reclaiming system. Regenerating cycle consists of regenerating first with 3° Bé. residue from previous regeneration. This is discarded to waste when followed by fresh 10° Bé. brine. Following residue passed to recovery tank and used for next regeneration.—*T. E. Larson.*

**Removal of Iron From Water by Means of Semicalcined Dolomite ("Magnomass").** S. A. VOZNESENSKII, A. V. EVLANOVA AND R. V. SUVOROVA. J. Applied Chem. (U.S.S.R.) **13:** 1304

('40). Filtration of water through filter prepd. from $CaCO_3 \cdot MgO$ removed Fe from water in amts. depending on thickness of filter ($H$). Relationship expressed by $H = Kd^n\sqrt{l}\ [lg(C_0/C)]$, where $K$ and $n$ are empirical constants, $l$ is velocity of filtration in m./hr., $d$ is diam. of dolomite particles in mm. and $C_0$ and $C$ are initial and final concn. of Fe in water in mg./liter. Fe remaining in water after filtration can be removed easily and in considerable amt. by filtration through sand filter. Such procedure recommended for water in which Fe hard to remove.—*C. A.*

**The Problem of Iron Removal.** O. M. BAKKE. Tex. W. W. Short School. **22:** 36 ('40). Consists in removal of $CO_2$ by appropriate aerators resulting in oxidation of iron. Softening should follow, not precede, removal of $CO_2$; otherwise iron will clog softener. Manganese, at present, removed by proper zeolite. First step in iron removal consists in adequate chem. anal. of water and competent eng. estimates as to choice of method, construction and operation of equipment.—*O. M. Smith.*

**American Water Softening Plants of Especial Interest.** L. J. ALEXANDER. W. W. & Sew. **87:** 520 (Nov. '40). Running account of observations made during tour of 19 typical plants. Paper noteworthy for recording faults in plant as well as successes. Following are some of outstanding things noted at various plants: *Oklahoma City.*—Scott-Darcy contact process for making ferrous chloride, sludge return, submerged combustion recarbonation, and lime sludge reclamation; *Topeka.*—double flocculation used with lime-soda treatment; *St. Louis County Water Co.*—baffled mixing proved unsatisfactory; *Mahoning Valley plant.*—flexibility and sludge disposal facilities noteworthy; *Bloomington, Ill.*—sludge precipitation in influent and effluent conduits reduced sedimentation efficiency, no recarbonation; *Elgin, Ill.*—plant poorly proportioned and inflexible, difficulty experienced with porous plate underdrains; *Canal-Winchester, Ohio*—sludge disposal serious problem.—*H. E. Hudson, Jr.*

**Water Treatment at Ypsilanti, Mich.** JAMES A. MOSIER. W. W. Eng. **94:** 560 (May 21, '41). Description given of water treatment plant operating as softening plant since Sept. '39. Water taken from 22, 8" wells, aerated, treated with lime and soda ash in 2 mixing and 2 coagulating basins equipped with vertical paddles, with variable speed arrangement in coag. basins. Settling takes place in clarifier basin and in 2 settling basins; primary basin equipped with straight-line sludge collector and second baffled. Water recarbonated before second settling and before filtration. Filters consist of 2 1-m.g.d. units with 18" gravel and 32" sand and with troughs having adjustable weir edges. Sludge return practiced and coagulant found necessary for best results. Ave. '40 daily consumption for city amounted to 1.32 mil.gal.; ave. chemicals, in lb. per mil.gal. used, as follows: lime, 1,882; soda ash, 361; chlorine, 0.32 p.p.m.; $CO_2$, 483; coagulant, 2.51 p.p.m. Total hardness reduced from 370 to 81 p.p.m. Efficiency of lime slaking greatly increased by introduction of heated water to slaker.—*Martin E. Flentje.*

**Modern Water-Softening Plant Now Serves Owensboro, Ky.** ANON. Am. City. **56:** 1: 67 (Jan. '41). Water for Owensboro, Ky. is obtained from 3, 18" Layne wells and 10 smaller driven wells. Hardness of combined raw rater is 270 p.p.m. which is reduced to 120 p.p.m. after softening. To accomplish this, water is first aerated to remove $H_2S$, treated with lime (return sludge from primary settling basin plus 1,000 lb. per mil.gal.), recarbonated with $CO_2$ (obtained from burning natural gas) and settled. 3 filters of 2-m.g.d. capac. complete treatment in new P.W.A. Utilities Bldg. which also houses munic. power plant. Wash-water tank, wet well, complete pumping equipment and elevated storage tank constitute remainder of well designed modernization program.—*F. J. Maier.*

**The Georgetown Water Softening Plant.** JEFF LOGAN. Tex. W. W. Short School. **22:** 35 ('40). If iron-bearing water softened by zeolite, best to soften first,

then aerate; otherwise, iron hydroxide will clog softener. For any given water one best method for softening. Results can best be obtained by running pilot plant to determine costs and results.—*O. M. Smith.*

**Edmonton Adds to Water Softening Plant.** ROBERT G. WATSON. Eng. Cont. Rec. **54**: 15: 8 (Apr. 9, '41). During '40 Edmonton, Alta., 89,000 pop., added to existing water works system 1-mil.-gal. concrete clear water storage basin and lime-soda softening plant. Clear water basin 163' x 140' of sloping sides. Floor and sides poured in alternate sections and expansion lip formed on all sides of slabs. These treated with hot asphalt and all vertical joints packed with oakum and asphalt. Softening plant consists of 4 mixing basins equipped with mechanical strainers, Dorr clarifier, carbonation chamber, flocculators, secondary settling basin equipped with Dorr monorakes, recarbonation basin and a third sedimentation basin. From latter, water passes to filters. Hardness of raw water, from North Saskatchewan R., averages 183 p.p.m. Will be reduced to 75 p.p.m. About 2–3 g.p.g. excess lime required to precipitate magnesium completely. All chemicals—chlorine, ammonium sulfate, alum, lime, soda ash and, at times, activated carbon—together with sludge returned from sedimentation basins, introduced in first mixing chamber. Activated carbon applied to remove swampy tastes during spring runoff. pH value reduced to 9.2–9.4 after first carbonation and to 8.1 after second application of carbon dioxide. Carbon dioxide produced by burning natural gas.—*R. E. Thompson.*

## TASTE AND ODOR CONTROL

**Threshold Tests, Old and New.** HENRY LAUGHLIN. Ohio Conf. W. Purif. 20th Ann Rept. ('40) p. 65. Efficiency of any process of taste and odor control can be determined only by threshold tests, and such tests, to be reliable, must be conducted without observer's knowing identity of sample being examined. If only one observer available, prepare at least 8 dilutions of water sample and blank of odor-free water, all of 250-ml. volume, heat to 60° C., place in mixed order, separate flasks on basis of presence or absence of odor, and note lowest dilution in odor-containing group. If 2 observers available (2nd observer need not be lab. worker), one should prepare dilutions and several blanks and pass them 2 at a time, dilution and a blank, to other for odor observation.—*R. E. Thompson.*

**Observations Regarding Break-Point Chlorination.** CLYDE H. IRWIN. Ohio Conf. W. Purif. 20th Ann. Rept. ('40) p. 41. Lab. expts. with Lake Erie water at Cleveland demonstrated that break-point chlorination was effective in destroying tastes and odors caused by algae, break-point being at 0.8 p.p.m. Plant data show that pre-chlorination (0.3–0.6 p.p.m.) increases threshold odor value an ave. of 20%. Increases up to 75% have been noted. These increases are probably due to chlorination below break-point. In expts. with water polluted with trade wastes and containing 0.410 p.p.m. phenol, chlorophenolic tastes disappeared when chlorine dosage exceeded break-point (1.6 p.p.m.) with 3-hr. contact period. Dosage of 6 p.p.m. and 2-hr. contact period required to destroy chlorophenolic taste in water to which 0.5 p.p.m. C.P. phenol had been plant added. Break-point tests also made on plant effluent and distr. system samples when ammonia-chlorine treatment employed. Residual chlorine content determined by both acid and alkaline iodometric methods. Nitrite seriously interferes with former—0.1 p.p.m. (expressed as nitrogen) gives rise to false residual chorine value of 0.34 p.p.m. on immediate titration and 0.58 p.p.m. if 1 min. allowed before titration; and 0.2 p.p.m. gives false values as high as 0.72 and 1.6 p.p.m. immediately and after 1 min., respectively. Up to 0.5 p.p.m. nitrite does not affect alkaline method. Orthotolidine reagent particularly sensi-

tive to nitrite, 0.005 p.p.m. giving color after 10 min. contact. From curves obtained by using both alkaline and acid titration methods, concluded that 0.6–0.8 p.p.m. chlorine, in absence of ammonia, required to remove 0.1 p.p.m. nitrite. With 0.36 p.p.m. ammonia in absence of nitrite, ratio of ammonia originally present to chlorine applied at crest of curve was 1:5.8 and at break-point, ratio of ammonia originally present (expressed as nitrogen) to chlorine dissipated was 1:11. Ratios when 0.1 p.p.m. nitrite present with 0.36 p.p.m. ammonia were 1:7.5 and 1:13, respectively. Indications that nitrite is compatible with chlorine in presence of ammonia to crest of curve to left of break-point. Beyond this point, nitrite absent. Amines and free ammonia exist to left of break-point but not to right of it. Facts may indicate that chloramines are formed up to crest of curve and, on addition of larger amounts of chlorine, are converted to nitrogen trichloride, recognizable by its odor at and, in some cases, past break-point. Contradictory to the supposed non-existence of nitrogen trichloride above pH 4.4. Ratios at break-points of all curves in excess of theoretical ratio for formation of nitrogen trichloride, namely 1:7.5 (approx.). Effect of dosages of chlorine equal to and in excess of theoretical ratio on residual chlorine contents indicated by acid and alkaline titrations shown by curves. Water containing concs. of urea and acetamide equivalent in nitrogen to 0.36 p.p.m. ammonia showed no break-point and very low chlorine absorption.—*R. E. Thompson.*

**Break-Point Chlorination as Used at Defiance for Odor Control.** FRANK S. TAYLOR. Ohio Conf. W. Purif. 20th Ann. Rept. ('40) p. 50. Tastes and odors of wide variety troublesome in Maumee R. supply of Defiance, Ohio, since '20. In Nov. '39, heavy rainfall following prolonged drought resulted in development of fishy odor after addition of lime and soda ash for softening Discontinuance of softening and increasing chlorine dosage from 2.75 to as high as 19.1 p.p.m., de-chlorinating with sulfur dioxide prior to filtration, corrected trouble. In Jan. '40, similar conditions led to odors of septic sewage nature. Discontinuance of softening gave no relief but increasing chlorine dosage to 14.9 p.p.m. successful, odor persisting in raw water. Larger chlorine dosages applied after partial softening, pH value being 9.6–10.0. Elsewhere, found that best results obtained with least amt. of chlorine and of sulfur dioxide for de-chlorination when pH value between 7 and 8. May be more economical, therefore, to superchlorinate prior to softening, pH value of raw water being 7.6–8.2. Lab. tests showed that chlorine dissipated faster at lower pH values. This confirms experience in swimming pool chlorination, chlorine residuals being difficult to maintain at pH 6.8–7.0 but maintained easily at pH 8.0. Further investigations will be carried out along these lines. *Discussion. Ibid.* p. 54, C. P. HOOVER: Need for better methods of controlling super-chlorination stressed. Unstable organic compounds may give false residual chlorine values as determined with ortho-tolidine.—*R. E. Thompson.*

**Studies in Preventing Chlorophenolic Tastes Using Ammonia, Carbon, and Excess Doses of Chlorine.** J. A. MARSH AND F. W. KLINGMAN. Ohio Conf. W. Purif. 20th Ann. Rept. ('40) p. 68. Phenol contents as high as 0.41 p.p.m. in raw water at Cleveland gave rise to chlorophenolic tastes when pre- and post-ammonia-chlorine treatment employed. Lab. expts. with samples of raw water to which 0.25–1.0 p.p.m. C.P. phenol had been added, showed that ratio of ammonia to chlorine required for prevention of taste increased with conc. of phenol and dosage of chlorine employed. With 0.25 p.p.m. phenol, ratios of 2–3:1 necessary when using 4, 5 and 6 lb. chlorine per mil. gal. At higher phenol concs., ratio of 4:1 required. Found also that raw water containing 0.1 p.p.m. added phenol and treated as in plant practice with 1 lb. ammonia and 3 lb. chlorine per mil.gal., free from taste, but after coagulation with alum, settling, filtering through

cotton and treating with plant post-dosages of 1.5 lb. ammonia and 5 lb. chlorine, chlorophenolic taste developed. In expts. with activated carbon, raw water containing 0.5 p.p.m. added phenol treated with 0.5 g.p.g. alum and 5–100 p.p.m. carbon, stirred 1 hr., allowed to stand 3 hr., filtered through washed cotton and then treated with chlorine. Chlorophenolic tastes occurred in all samples treated with small amounts of chlorine, and absent with carbon above 20 p.p.m. and 0.12 p.p.m. chlorine, and with carbon above 40 p.p.m. and 0.24 p.p.m. chlorine. Strong chlorophenolic tastes present in all samples to which had been added 0.36 and 0.6 p.p.m. chlorine. Less carbon would probably be required in practice owing to its retention in filters. In similar series in which chlorine was applied immediately after phenol, chlorophenolic taste produced by 0.24 and 0.36 p.p.m. chlorine removed with 10 p.p.m. carbon and that produced by 0.48, 0.6 and 0.72 p.p.m. removed with 40 p.p.m. or more of carbon. Addition of 0.12 p.p.m. chlorine to taste-free water so produced, however, caused chlorophenolic taste to reappear, indicating that all phenol had not been removed. In another series of tests, on raw water containing 0.5 p.p.m. added phenol, 1–13 p.p.m. chlorine was added in 1 p.p.m. increments. All samples developed chlorophenolic taste, stronger in lower dosages, but after standing 2 hr. all samples which had been treated with more than 6 p.p.m. chlorine were free from taste. To determine relative bactericidal efficiency of chlorine and ammonia-chlorine treatments, samples of filtered water containing chlorine-resistant non-gas-forming bacteria which produced heavy growth in lactose broth were treated with 0.1–0.9 p.p.m. chlorine in 0.1 p.p.m. increments, with and without ammonia added in ratio of 1:3 of chlorine. After standing 24 hr., 10-ml. portions were planted in lactose broth and incubated for 48 hr. at 37.5°C. Of 279 samples so examined over 3-month period, 97, or 35%, of those treated with chlorine alone showed growth compared with 150 or 54% of those treated with ammonia-chlorine. In samples with chlorine dosage above 0.4 p.p.m., 35, or 12.5%, treated with chlorine alone and 68, or 24%, treated with ammonia-chlorine showed growth. At lower temps., chlorine alone was much more effective than ammonia-chlorine. —*R. E. Thompson.*

**Electric Water Purification.** J. B. KLUMPP. Elec. World. **115:** 617 ('41). Description of new $O_3$ processing equipment designed for adaptation in munic. water works. Has been found that objectionable tastes, odors and discoloration of water can be removed with 10 lb. of $O_3$ per mil.gal. $H_2O$. Over-all energy consumption amts. to 12 kw.hr. per lb. $O_3$. Before air is dried it passes through elec. precipitator to remove all dust. Compressed, dried, clean and cooled air enters ozonator (elec. discharge 8,000 to 16,000 v.) and finally into water. Here thorough mixing takes place and complete sterilization of water assured. Various large-scale installations (up to to 79 mil.gal. $H_2O$ per day) briefly referred to.—*C. A.*

**Lime and Lime Slaking.** H. E. LORDLEY. W. W. & Sew. **87:** 551 (Dec. '40). Properties of lime depend on source of limestone and on method and control of processing. Use of pebble lime gives greatest economy and freedom from dust. Hydrated lime more costly than quicklime. Slakers finicky. Temp. must be between 150 and 180°F. In smaller plants feed water heating and control are desirable. At Richmond, Va., dust and vapor removed with injector whose output is used to dilute and convey lime slurry. Open trough for conveying suspension most easily kept clear. New gravimetric feeder improves control over finished water quality.—*H. E. Hudson, Jr.*

**Magno-Iron Sol, a New Coagulant for the Purification of Water.** HANS BORNER. Gas-u. Wasser. (Ger.) **83:** 589 (Nov. 23, '40). Present coagulants ferric chloride, ferric sulfate, alum, copper sulfate and sodium aluminate have certain drawbacks in that they require optional pH values, hard water or addition of lime, and much time for floc

formation especially at low temps. To avoid these difficulties, new powdered preparation, "Magno-iron sol dry," developed and German patents have been applied. Used in 10% soln. Material especially suitable for highly colored soft water with high oxygen consumption. If ferric chloride used, 3 stages can be differentiated in production of floc. Represented by following equations:

$$2\,FeCl_3 + 6\,H_2O \rightleftarrows Fe_2(OH)_6 + 6\,HCl$$

$$5\,FeCl_3 + 12\,H_2O + 6\,Ca(HCO_3)_2 \rightarrow 2\,Fe_2(OH)_6 + FeCl_3 + 6\,CaCl_2 + 12\,H_2CO_3$$

$$Fe_2(OH) + 2\,FeCl_3 + 3\,Ca(HCO_3)_2 = 5\,Fe_2(OH) + 3\,CaCl_2 + 6\,CO_2$$

Floc is formed only in third stage. If, therefore, iron hydroxyl sol is directly introduced, time required for first two stages eliminated; carbonate hardness consumed in second stage available for third stage and aggressive acids formed in first two stages not fully produced. Further found that reactions also take place at lower pH and temp. If humic acid compounds present in water, they form negatively charged hydrophobe colloids. These do not coagulate with positively charged ferric hydroxide floc owing to their water content. Yet coagulation occurs if an electrolyte is added to water. This reaction obtains from the calcium and magnesium chloride contained in magno-iron sol. Iron is present in water in molecularly or in colloidally dispersed form. If latter is combined with humic acids, cannot be removed by aeration and filtering. Tests with new coagulant show that it will remove such iron. Partial results of tests are given, but not composition of coagulant.—*Max Suter.*

**Coagulation of Water With Ferrous Sulfate.** A. M. ZHUCHKOVA. Teplo-Silovoe Khoz. (U. S. S. R.) No. 7: 51 ('39); Khim. Referat. Zhur. No. 12:86 ('39). Lab. and production expts. carried out with use of $FeSO_4$ as coagulant. 1-phase soda-lime equipment used simutaneously for both coagulation and softening of water. Advantages of proposed method over $Al_2(SO_4)_3$ method are: (1) effect of coagulation with simultaneous treatment of water with $FeSO_4$, soda and lime is greater than in treatment with coagulant alone; (2) $Fe(OH)_3$ which is formed in this process is insol. in water; (3) residual hardness of softened water and content of org. substances are lowered considerably. Oxygen demand of water is lowered from 39.4 to 4.8 mg./liter, and, simultaneously, water is softened to 0.55–0.65° (German). Expts. performed at 40–5°. Defect of proposed method is presence of suspended fine ppt. of $Fe(OH)_3$ in softened water. This is attributed to short time of settling of water and to poor performance of wood-shaving filter in equipment.—*C. A.*

**Alkalinity and pH Studies With Various Coagulants.** E. B. EVANS AND B. S. SHUEY. Ohio Conf. W. Purif. 20th Ann. Rept. ('40) p. 79. Ferrous sulfate ($7\,H_2O$) has been used as coagulant at Cincinnati for 32 yr. When plant was reconstructed several yr. ago, dry feed substituted for soln. feed and considerable difficulty developed due to caking. Addition of bentonite experimented with, but segregation rendered such addition ineffective. Dried ferrous sulfate found satisfactory, although some caking still occurs. Product, however, can be obtained from only few manufacturers. Accordingly, other coagulants are being experimented with in lab. Alkalinity and pH of samples treated with various amounts of alum and lime, Ferrisul and lime, and ferrous sulfate and lime presented in tables and graphs. Well established in Cincinnati that to prevent corrosion in distr. system, final pH value should be 8.4–8.6. As pH value decreases during filtration, applied water pH must be 8.8 or higher. Min. dosage of lime (88% CaO) to maintain pH in this range is 0.8–1.0 g.p.g. for dosages of above coagulants up to 1.2 g.p.g. In case of both iron coagulants, min. dosage for good floc formation was observed to be about 0.6–0.8 g.p.g. Both Ferrisul and alum gave good flocculation at low pH values, whereas higher pH values are more favorable for ferrous sulfate. At higher pH values, Ferrisul dosages above 0.6 g.p.g. gave better flocculation than filter alum.—*R. E. Thompson.*

**Alumina Floc. X-Ray Diffraction Study.** HARRY B. WEISER, W. O. MILLIGAN AND W. R. PURCELL. Ind. Eng. Chem. **32:** 1487 (Nov. '40). According to x-ray and electron diffraction studies, alumina floc consists of hydrous mass of minute crystals of $\gamma$-$Al_2O_3 \cdot H_2O$ ($\gamma AlOOH$). Size of primary crystals in $\gamma$-$Al_2O_3 \cdot H_2O$ floc increases with increasing pH of soln. from which it separates. In alk. soln., transformation of $\gamma$-$Al_2O_3 \cdot H_2O$ to $\alpha$-$Al_2O_3 \cdot 3H_2O$ is fairly rapid. At given pH, size of primary crystal decreases in order NaOH, $NH_4OH$, $Na_2CO_3$, $Na_2S$. Primary crystals of $\gamma$-$Al_2O_3 \cdot H_2O$ show progressive increase in size after 1 to 24 hr. contact with mother liquor. Primary crystals of $\gamma$-$Al_2O_3 \cdot H_2O$ increase in size with decreasing concn. of aluminum sulfate. Aluminum sulfate and sodium carbonate at pH 5.5 to 6.5 form most highly dispersed crystals of $\gamma$-$Al_2O_3 \cdot H_2O$.—*Selma Gottlieb.*

**Alumina Floc.** HARRY B. WEISER, W. O. MILLIGAN AND W. R. PURCELL. Ind. Eng. Chem. **33:** 669 (May '41). Earlier conclusion confirmed that alum floc in water purif. practice is $\gamma$-$Al_2O_3 \cdot H_2O$, free of basic sulfate. Breaks in potentiometric titration curves for aluminum sulfate, nitrate and chloride at pH 4 found not to furnish conclusive evidence of basic salt formation but are due to free acid in original salt. X-ray diffraction patterns of flocs freshly formed below pH 5.5 show in addition to $\gamma$-$Al_2O_3 \cdot H_2O$, another compd., identified (after aging), by further x-ray study, chemical analysis and dehydration isobar, as $Al_2O_3 \cdot SO_3 \cdot 1.5\ H_2O$. No indication that more than one definite basic sulfate exists. Gels prepd. from aluminum nitrate and aluminum chloride solns. at about pH 4.0 are found to be $\gamma$-$Al_2O_3 \cdot H_2O$. No indication that basic aluminum nitrate or chloride can be prepd. under conditions that yield definite basic sulfate.—*Selma Gottlieb.*

**Accelerated Clarification.** FRANKLYN J. LAMMERS. J. N. E. W. W. A. **54:** 447 (Dec. '40). Recent development of compact high-rate equipment for lime softening has focused attention on possibility of using similar equipment in ordinary coagulation problems. Basins embodying central agitating mixing zone inside standard circular clarifier, direct upflow basins with mixing outside of settling basin and flow upward through blanket of sludge, upflow through sludge blanket in basin with conical section to obtain decreasing flow rate with mixing and clarification in same basin, similar type employing rotary distributor, and equipment utilizing large amts. of retained sludge to speed up chemical and physical reactions involved in coagulation have been used.—*Martin E. Flentje.*

## CHEMISTRY

**A Colorimetric Method for Estimation of Dissolved Oxygen in the Field.** M. L. JOHNSON AND R. J. WHITNEY. J. Exp. Biol. (Br.) **16:** 56 ('39). Describes adaptation of Winkler method for determination of oxygen, whereby amt. of iodine liberated estimated by strength of purple color developed when iodine has been taken up in given amt. of chloroform. Color matched against glass discs standardized against chloroform extracts of solns. of known oxygen content and treated with Winkler reagents. Sample of water treated with Winkler reagents, avoiding contact with air; 10 ml. of resulting iodine solution poured into stoppered measuring cylinder and an equal amount of chloroform is added. The mixture is shaken for 30 sec. and transferred to comparator tube. When chloroform separated out, color matched against standard discs. Method tested several times with samples containing from 1.0 to 6.8 ml. per liter oxygen and gave very consistent results. Readings obtained by method agreed fairly well with results of titration; absolute error increased with increasing content of oxygen, but percentage error remained fairly constant and was of the order of 5%. Syringe pipette may be used with method after certain adjustments permitting required quantity of chloroform to be drawn in after liberation of iodine in

syringe, and chloroform-iodine solution to be rapidly ejected. Details given of procedure in analysis using syringe pipette.—*W. P. R.*

**Determination of Dissolved Oxygen in Solutions, Particularly in Presence of Magnesium Salts.** W. Katz. Kali. (Ger.) **35**: 27 ('41). Winkler's iodometric method, based on oxidation of manganous hydroxide by oxygen at high pH, does not work well in presence of much magnesium, partly because of formation of slimy precipitate of magnesium hydroxide, but chiefly because magnesium salts act as buffer on hydroxide ion and make it difficult to maintain desired pH. Fairly accurate results obtained, provided care taken to avoid contact with air, by adding about 0.1 gram Mohr's salt to 150 ml. water in 150-ml. stoppered bottle and about 0.1 gram magnesium oxide. After occasional shaking during about 2 hr., soln. made acid with hydrochloric acid and ferric iron content determined colorimetrically by thiocyanate method. If copper present, oxygen value calculated from ferric iron formed must be reduced by 0.13 mg. per liter for each 64 mg. of copper present.—*C. A.*

**Oxidation-Reduction Potentials in Water-Logged Soils, Natural Waters and Muds.** W. H. Pearsall and C. H. Mortimer. J. Ecol. (Br.) **27**: 483 ('39). Oxidation-reduction potentials of wet soils, determined in field by electrometric method, compared with their ratios of ferrous to ferric iron and their oxidizing action on diphenylamine. Latter is test for nitrate in absence of other oxidizing agents. In general, ferrous iron not found, nor was diphenylamine oxidized until potential exceeded value of about 350 mv. (corrected to pH 5). Samples of lake water containing lake mud and ferric chloride did not contain free ferrous ions until potential fell below 350 mg. In samples of water taken at various depths from Blelham Tarn, oxidation-reduction potential fell as depth increased; ferric iron, nitrate, and sulfate found when potential exceeded 350 mv., and ferrous iron, ammonia, and sulfide found when potential less than this value. Measurements of oxidation-reduction potential of lake water by potentiometric method and by indicator method agreed. Aeration of water raised potential. When reducing, lake mud covered with water and exposed to air, oxidation proceeds from surface of mud downwards when distribution of oxidation products found to depend on oxidation-reduction potential. Same critical value of about 350 mv. found. In soils, in natural waters, and in muds, change from oxidizing to reducing conditions coincides with oxidation-reduction potential of about 350 mv. (corrected to pH 5). In natural waters, change coincides with conc. of dissolved oxygen which is about 8% of saturation. Factors likely to affect observed potentials discussed.—*W. P. R.*

**Methods of Removing Free Carbon Dioxide From Natural Waters.** E. L. Streatfield. J. Soc. Chem. Ind. (Br.) **58**: 313 ('39). So-called "free" carbon dioxide, if present to any extent in water for public supply, results in corrosive action of water on mains, etc., and in deterioration of synthetic base-exchange substances used for softening water. Chem. methods of removal of this carbon dioxide using filtration through marble or "Magno" filters, or addition of lime, practicable only with soft waters, as they increase hardness. Expts. carried out on removal by sodium carbonate and sodium hydroxide, and by aeration. Detn. of carbon dioxide was by direct titration with sodium carbonate. Water used in expts. obtained from chalk wells. Used for supply and softened by base-exchange process before distr. to consumers. Necessary to reduce content of free carbon dioxide, before softening, from ave. of 45 p.p.m. to 10–20 p.p.m. Addition of sodium carbonate or sodium hydroxide to water effected degree of reduction of free carbon dioxide equal to theoretical without appreciable precipitation of calcium carbonate. Effect of aeration studied by means of cascading from central pipe over no. of circular trays; air could be injected into water in pipe. This effected considerable reduction in carbon dioxide. Reduction in-

creased slightly by increase in rate of flow; in given vertical distance, it increased with increase in number of trays or quantity of air used, or both. With large fountain cascade with diffusion of air at rate of 83.5 cu.ft. per 1,000 gal. of water and using 5 trays in vertical distance of 10′ 6″, content of free carbon dioxide reduced from 46 to 10 p.p.m. at rate of flow of 3 m.g.d., i.e., removal of 78.3%. Aeration of water by cascading over no. of concrete steps also studied on small scale; results indicated that, on large scale, removal of free carbon dioxide equivalent to that affected on large fountain cascade could be obtained in slightly smaller vertical height.—*W. P. R.*

**Microdetermination of the Total Dissolved Carbon Dioxide (in Pond Water).** KEN SUGAWARA AND TADASIRO OYAMA. J. Chem. Soc. (Japan) **61:** 1017 ('40). Boil sample with sulfuric acid, absorb liberated carbon dioxide in measured vol. of barium hydroxide and titrate excess barium hydroxide with hydrochloric acid to phenolphthalein endpoint.—*C. A.*

**Automatic Detection of Dangerous Concentrations of Chlorine in Air.** I. V. MEN'SHCHIKOV. Zavodskaya Lab. (U.S.S.R.) **9:** 1240 ('40). Air passed through spiral absorber through which flows stream of solution, 0.00011 *N* in methyl orange, 0.5 *N* in sulfuric acid and contains 0.05% potassium bromide and 2% ethyl alcohol. More or less decolorized solution passed through gas separator then through tube examined automatically in photocolorimeter.—*C. A.*

**Reaction of Hypochlorite Ion With Nitrites.** N. M. VAKSBERG. J. Applied Chem. (U.S.S.R.) **13:** 1504 (*in French,* 1511) ('40). Velocity of reaction between chlorine and nitrite depends on pH of medium. Thus, nitrite at pH 6 and lower oxidized practically instantaneously and completely, whereas at high pH, velocity decreases with increase of pH and more chlorine and nitrite remain unchanged. Equilibrium depends not only on pH but also on initial concentration of chlorine and nitrite, temp., composition of medium and other factors.—*C. A.*

**Sources of Error in the Colorimetric Estimation of Nitrogen With Nessler's Reagent.** MAX HERTER. Deut. Apoth.-Ztg. (Ger.) **55:** 375 ('40). Expts. show that certain errors incident to mineralization and subsequent treatment can be eliminated by following procedure: Mineralize with mixture of 80 ml. sulfuric acid (1.84), 17 ml. water and 3 ml. 10% soln. of crystalline copper sulfate. For Nessler's reagent, add 15 grams mercuric iodide to solution of 11.25 grams potassium iodide in 7.5 ml. hot water, and dilute with water to 75 ml. After 2 days, dilute further with 75 ml. water, then mix with soln. of 90 grams sodium hydroxide in 600 ml. water, and finally dilute to 1 liter. Soln. ready for use when turbidity has settled (2–3 days). Pour or pipet off clear liquid from yellow sediment.—*C. A.*

**Inhibition of Nitrification by Chromates.** S. H. JENKINS AND C. H. HEWITT. Nature. **147:** 239 ('40). From 5 to 10 p.p.m. of Cr in form of $K_2CrO_4$ in sewage arrested production of nitrate and nitrite from $NH_3$ by activated sludge completely within 48 hr. Inhibitory action lasted 1 wk. after removal of inhibiting agent.—*C.A.*

**The Importance of Temperature for Colorimetric Determinations With Special Reference to Nessler's Reaction.** LUDWIG PINCUSSEN. J. Lab. Clin. Med. **26:** 1062 ('41). Intensity of color produced by adding Nessler's reagent to ammonium sulfate solutions obtained by digesting urine with sulfuric acid varies with change in temp. When colorimeter used in this determination, solns. in both cups must be maintained at same temp. during matching of colors.—*C. A.*

**Recovery of Mercuric Iodide and Iodine From Nesslerized Solutions.** G. WEBER SCHIMPFF AND RUSSELL E. POTTINGER. Ind. Eng. Chem.—Anal. Ed. **13:** 337 (May '41). For recovery of mercuric iodide and iodine from Nesslerized solns., 10-liter lot treated with 150 ml. concd. $H_2SO_4$, followed by 75 ml. of 1.3 *M* $Na_2Cr_2O_7$ soln. After standing 12 hr., covered, for pptn. of $HgI_2$, supernatant liquid decanted and residue transferred

to flask, water added and I vapors boiled off and collected on cooled surface. $HgI_2$ in flask filtered off, washed with 95% EtOH and dried. Recovery 95.7% for $HgI_2$, and 92.2% for I. Nessler-Folin reagent prepd. by adding 40.3 grams recovered $HgI_2$ (instead of 30 grams Hg and 22.5 grams I) to 30 grams KI in 30 ml. $H_2O$. Soln. filtered, adjusted with soln. of recovered I in KI and diluted to 200 ml. This stock soln. added to 975 ml. 2.5 *M* NaOH for use. No difference observed in behavior of solns. prepd. by two methods.—*Selma Gottlieb.*

**Colorimetric Determination of Copper With Triethanolamine.** J. H. Yoe and C. J. Barton. Ind. Eng. Chem.—Anal. Ed. **12:** 456 ('40). To avoid strong odor and loss of reagent which occurs when aqueous ammonia used in colorimetric detn. of copper, authors investigated use of substituted ammonias, particularly triethanolamine. Colored solns. obtained examined with spectrophotometer. With increasing concs. of triethanolamine, transmission of light reached min. at 3.5% and then practically constant. With ammonia, transmission still decreasing at about 3 molar concs. Conc. of triethanolamine has less effect than that of ammonia on transmission of light by solns. contg. 100 p.p.m. copper. Effect of presence of triethanolamine and ammonium salts detd.; found that former slightly increased, and latter slightly decreased transmission. Ammonia-copper solns. conformed with Beer's law, but triethanolamine-copper solns. did not, probably owing to changes in composition of triethanolamine-copper complex. Triethanolamine method slightly more sensitive than ammonia method at low copper concs.—*W.P.R.*

**The Determination of Small Quantities of Lead With Dithizone.** H. Fischer and G. Leopoldi. Z. Anal. Chem. (Ger.) **119:** 161 ('40). Describes precautions necessary to ensure absence of lead from apparatus and reagents employed in detn. of small quantities of lead. Two methods by which lead extracted by dithizone may be determined—one-color and two-color processes. In former lead is extracted from aqueous solution by dithizone in carbon tetrachloride; slight excess of green dithizone destroyed by shaking with dilute soln. of potassium cyanide. At this stage, red color of lead dithizonate in carbon tetrachloride may be compared directly with that of solns. similarly prepared containing known amts. of lead or, alternatively, lead dithizonate may be destroyed with hydrochloric acid to yield equivalent of green dithizone in soln. Colorimetric comparison of green soln. with standard dithizone solns. serves as basis for detn. of lead. Sources of error involved in one-color method largely eliminated by identical treatment of unknown and standard solns. In two-color method, lead extracted from soln. (pH 9.5 to 10) by soln. of dithizone in chloroform. Extract treated with dilute nitric acid and second extraction of lead carried out; resulting color of extract is mixture of red and green due to lead dithizonate and excess of dithizone. Lead may be detd. by examining this mixed color with absolute colorimeter, readings of which have been standardized for lead, or chloroform soln. of dithizone of conc used may be placed in second vessel and standard soln. of lead titrated into it until mixed color is same in chloroform extracts in both vessels. Use of mixed colors already applied by authors in detg. copper and zinc in small quantities. During extraction of lead, appreciable amounts of potassium cyanide must be used to prevent simultaneous removal of other heavy metals by carbon tetrachloride solutions of dithizone. pH of liquid being treated may be greater than 10, but this without influence upon accuracy of detn. of lead. Exptl. details given for extraction and detn. of lead in presence of oxidizing agents and copper, bismuth, tin, and thallium. 56 refs. to papers dealing with use of dithizone as reagent for qualitative and quantitative detn. of lead.—*W.P.R.*

**The Calcium Complexes of Sodium Hexameta- and Tripolyphosphate.** Hermann Rudy, Hildegard Schloesser and Rudolf Watzel. Angew. Chem. (Ger.) **53:** 525 ('40). $Na_6P_6O_{18}$ (I) forms calcium complexes more readily than does $Na_5P_3O_{10}$ (II). This behavior

observed both in prevention of pptn. of calcium soap and in soln. of calcium soaps. Latter property strongly dependent on temp. and at about 80°, difference in action of I and II is small. Tetrapolyphosphate ($Na_6P_4O_{13}$) probably mixture, properties of which lie between those of I and II. Pyrophosphate ($Na_4P_2O_7$) shows only small tendency to form calcium complexes and action depends largely upon formation of difficultly soluble calcium salts. Neither tetrametaphosphate nor trimetaphosphate forms calcium complexes. In pH range 8 to 9 and at room temps., I and II form complexes $Na_4CaP_6O_{18}$ and $Ca(Na_4P_3O_{10})_2$; excesses of 0.25 mol. I and about 1.3 mol. II, respectively, necessary to reduce equilibrium calcium concentrations in dissociation reaction to prevent precipitation of calcium soaps. Many exptl. data and 36 refs. given. —*C. A.*

**Mercurometric Method of Determining Chloride in Weakly Mineralized Drinking Water.** L. N. Lapin and V. P. Moroz. Zavodskaya Lab. (U.S.S.R.) **9:** 1247 ('40). Most suitable indicators in mercurometric detns. are diphenylcarbazide and diphenylcarbazone, introduced into volumetric analysis by Dubský and Trtílek (Chem. Abstracts **27:** 2107). Use of alc. increases sharpness of coloration at end of titration to such extent that makes it possible to employ 0.0005 *N* $Hg(NO_3)_2$. Evap. 25 ml. of water in porcelain cup, cool, add 1 ml. of 0.5 *N* $HNO_3$, mix with glass rod, add 20 ml. alc. and drop of carbazone and add gradually from a microburet enough of 0.01 *N* $Hg(NO_3)_2$ to give definite violet tint. If alc. freshly distd., blank titration should not require more than 0.01 ml. of 0.01 *N* $Hg(NO_3)_2$. Method sufficiently sensitive to be used for detn. of chloride in rain water and in snow.—*C. A.*

**A Colorimetric Method for the Determination of Small Quantities of Chloropicrin in Air, Water and Food.** W. Deckert and B. Prathithavanija. Z. Anal. Chem. (Ger.) **113:** 182 ('38); Gas. u. Wasserfach. (Ger.) **82:** 30 ('39). Small quantities of chloropicrin in air, water, and food may be estimated by shaking sample under investigation with 50% soln. of dimethylaniline in benzene. After separation of layers and heating with hydrogen peroxide, dimethylaniline solution will, in presence of chloropicrin, have a color ranging from light yellow-red to deep blood red according to conc. of chloropicrin. Concs. as low as 0.5 mg. per liter of water can be detd. quantitatively by this method; about 2 mg. per liter can be detected by taste or smell.—*W. P. R.*

## BACTERIOLOGY

**Research and Control.** Norman J. Howard. Can. Engr.—Wtr. & Sew. **79:** 3: 19 (Mar. '41). Significance of coliform organisms in water, and current practice in their isolation are discussed. Many believe that attenuated forms of lactose-fermenting bacteria are index of remote pollution that is of little san. signif. Reasonable to assume, however, that attenuated strain may become virulent in susceptible individual. Problem further complicated by lack of generally accepted method of distinguishing fecal from non-fecal strains. In case of open reservoirs, excretions of fish and gulls may introduce coliform organisms indistinguishable from human fecal strains. For practical purposes, therefore, can be assumed that domestic water supplies should be free from all types of lactose-fermenting bacteria. During past 25 yr., 3 chief primary media—dextrose broth, lactose broth and lactose bile—have been employed for isolation of coliform bacteria. Later, addition of triphenylmethane dyes to latter medium investigated. Such additions found to reduce isolation of coliform bacteria 2–5% and, consequently, use of such media never adopted as standard practice. Unfortunately, no one medium seems suitable for all types of waters. Brilliant green bile (B.G.B.) found unsatistactory in some cases and this largely responsible for its not being approved as standard medium. Author, however, knows of no

instance in which B.G.B. failed to give satisfactory results on waters known to be polluted with sewage. In such waters, lactose broth has been shown to be of limited value due to overgrowths. Recent study by McCrady and his associates showed that MacConkey's bile salt broth, as used in British practice, inferior to either standard lactose broth or B.G.B., and also, that direct inoculation of lactose broth presumptive positives into B.G.B. as confirmatory procedure is as satisfactory as more involved "completed test" of *Standard Methods*. Author hopes that use of B.G.B. as confirmatory medium will soon become standard practice. Has been used in Toronto both as primary and confirmatory medium since '26 and similar methods have been employed in New York City for many years.—*R. E. Thompson.*

**Avoiding Errors in Handling Bacterial Samples.** Frank G. Manning. Sew. Wks. Eng. **12:** 318 (June '41). Manner of handling, storing and transporting sewage samples for analysis materially affects results. When time elapses between collection and incubation, questions arise as to need for icing, effect of residual chlorine, most practical and convenient method of transportation, and importance of skill in lab. technic of collecting and handling. Interstate Sanitation Com. sponsored lab. investigation to answer these questions. Samples collected and handled as follows: (1) Stored in 150-ml. sterile bottles and transferred to lab. at end of run. Lactose broth culture tubes inoculated in lab. (2) Stored in 150-ml. sterile bottle containing $\frac{3}{4}$ ml. thiosulfate soln. (1.5 grams per 100 ml. distilled water). Lactose broth culture tubes inoculated in lab. (3) Stored in 150-ml. sterile bottle containing $\frac{3}{4}$ ml. thiosulfate soln. as in (2). As soon as taken, bottle placed in ice in 1-gal. thermos jug. Bottles removed in lab. and lactose broth culture tubes inoculated. (4) Lactose broth culture tubes inoculated at plant and placed in incubator immediately on arrival at lab. Not more than 1 hr. elapsed between incubating of 1st and 4th sets. 24 and 48 hr. pos. presumptives were transferred to Bacto brilliant green bile 2% with 3 mm. loop. Gas production in 24 or 48 hr. considered confirmatory for coliform group. Results tabulated as follows:

| METHOD | SAMPLES SHOWING COLIFORM ORGANISMS | TUBES CONFIRMING COLIFORM ORGANISMS |
|---|---|---|
| Untreated | 81 | 166 |
| Treated | 100 | 380 |
| Treated and iced | 98 | 314 |
| Field set | 99 | 307 |

Concluded that coliform index much less in samples not treated with reducing substance to eliminate residual $Cl_2$. Samples treated with thiosulfate give materially high results. Insufficient $Cl_2$ to maintain residual, gave abnormally high results on storage. When investigator has acquired adequate technic for inoculating tubes directly in field, Method 4, results comparable to or better than those by Method 3 can be expected. Interstate San. Com. uses Method 4 for all routine investigations. All fermentation tubes planted directly in the field by investigators who have previously had supervised lab. experience in this procedure.—*Ralph E. Noble.*

**Interpretation of Bacteriological Analysis.** G. R. Herzik. Tex. W. W. Short School. **22:** 46 ('40). Interpretation, in terms of sanitary quality of water, demands not only careful consideration of such factors as seasons, nature and topography of source of supply, frequency of examination, etc., but also considerable experience. Full understanding not reached as to meaning of all data obtainable in lab., and conclusions still, to some extent, reflect individual experiences and therefore are variable. Discussion of standards as set forth in Tex. follows.—*O. M. Smith.*

**Supplemental Techniques Used in Bacteriological Studies of Water Supplies.** William E. Burns. (*Published in abstract only.*) J. Bact. **42:** 146 (July '41). Methods used in project inaugurated by Ohio River Pollution Survey to study

water-borne epidemics of gastro-enteritis presented. Raw and treated waters studied with recovery of species classified as *Salmonella*, *Shigella*, *Eberthella*, *Pseudomonas*, *Alcaligenes*, *Proteus*, and many forms of coliform organisms which fail to appear by *Standard Methods* technique. By new methods, first isolation of *Salmonella typhimurium* from city water meeting standards accomplished. Organisms of genus *Pseudomonas* have been encountered in waters causing gastro-enteritis outbreaks and should be regarded with suspicion. Methods of isolation and identification given. With use of presumptive coliform standard technique as enrichment method, procedure of isolating cultures outlined. Needle with ball 1.5 mm. diam. at end and smaller needle of same type for fishing colonies were used for streaking plates. Method of concentrating bacteria, from larger amounts of water, on small diatomaceous disc and their growth in enrichment media presented.—*Ralph E. Noble.*

**Chemical and Bacteriological Studies of Peptones.** A. E. Hook and F. W. Fabian. (*Published in abstract only.*) J. Bact. **41**: 30 (Jan. '41). 10 peptones prepared from animal tissues, 4 from hydrolyzed and 2 from unhydrolyzed corn gluten. Chem. analyses of these and 16 commercial peptones made for total, total-and-primary proteose, peptone, free-ammonia, free amino acid, amino nitrogens and ash content. Results showed much variability. Initial pH varied from 7.6 to 4.89. Least buffering action found between pH 5.5 and 7.5. Studies to determine ability of prepared peptones to support growth of bacteria included observations on growth rate of *Esch. coli*, plating of samples of raw milk, growth and gas production by coliform organisms found in naturally contaminated water, and growth of certain pathogenic organisms. Results show certain of prepared peptones superior to common commercial brands.—*Ralph E. Noble.*

**Peptones for Bacteriological Use Prepared by the Enzymic Digestion of Casein.** Einar Leifson. (*Published in abstract only.*) J. Bact. **41**: 31 (Jan. '41). Present report deals with parts of investigation undertaken to secure most suitable peptones for bacteriological use. Concerns only preparation of peptones from casein through use of pepsin, papyotin, and pancreatin. Casein was digested with each enzyme, employing various concs. of latter with casein. Various temps., acidities, and time periods for digestion studied. Each lot tested for growth-promoting properties with many kinds of bacteria. Each preparation also tested for usefulness in methyl-red and Voges-Proskauer test, production of indole, etc. From more than 50 lots of peptone, 3 basic types selected, each having been prepared with different one of the 3 enzymes. These basic peptones free from NaCl. Ash varied from 1 to 2%. Best peptone for general bacteriological purposes made by pancreatic digestion. For growth of pneumococci and $\beta$-hemolytic streptococci, however, papyotic digest best. Peptic digests appear to be inferior to other types.—*Ralph E. Noble.*

**A Comparative Study of Standard Agars for Determining Bacterial Counts in Water.** W. L. Mallmann and Robert S. Breed. Am. J. Pub. Health. **31**: 341 (Apr. '41). Study made of bacterial counts on waters from various sources using *Standard Methods* agar (hereinafter called "old" agar) and recently introduced standard agar for milk analysis (called "new"). Comparisons made on swimming pool, well, treated and untreated lake waters and chlorinated sewage effluents. In these, 87 samples gave ave. count of 14 bacteria per ml. on new agar when parallel old agar plates were zero; on 319 samples in which old agar count was between 0 and 6, ave. count on old agar was 1.2 and on new, 3.14; similarly in range of 6 to 10, ave. on old was 7.5 as against 12.41 on new. Data demonstrated inability of old agar to grow all bacteria in water capable of growth at 37°C. Authors conclude: (1) counts on new agar relatively high when old standard plates sterile; (2) when count on old 5 or more, parallel plates on new agar gave higher ave. counts but not sufficiently higher to make differences

significant; (3) new agar could be substituted for old without causing significant misinterpretations of data.—*Martin E. Flentje.*

**A Method for Determining the Hardness of Agar.** Alden F. Roe. (*Published in abstract only.*) J. Bact. **41:** 48 (Jan. '41). Apparatus constructed for evaluating hardness or turgidity of agar involves measuring pressure (in mm. of mercury) required to force cylinder of agar through fine-mesh screen under conditions sufficiently standardized to permit duplication. Some conditions found necessary to control are: rate of temp. change from liquid phase (soln. of agar in water) to solid phase (soln. of water in agar); temp. of testing; pH; concentration of salt, etc. Data on hardness of several commercial agars presented. Found that most non-solidifying gum and other organic and inorganic substances may be removed from finely ground, crude agar by infusion in changes of water at 50°C. Final steps in preparation include freezing, thawing, pressing, drying at 100°C., and regrinding. Suggestions regarding minimal requirements of agar that is to be incorporated in bacteriological media proposed.—*Ralph E. Noble.*

**Studies in Bacterial Counts.** Glenn Green. Ohio Conf. W. Purif. 20th Ann. Rept. ('40) p. 59. Effect of vibrating water samples, prior to plating on standard agar, as compared with shaking vigorously 25 times as prescribed in *Standard Methods* investigated. Vibrator used had frequency of 60 per sec., and period of vibration employed was 5 min. In series of exams. extending over 47 days, ave. raw water count using standard procedure was 873 per ml., while after vibration ave. was 1,459 per ml., increase of 67%. Similar results obtained with milk. Vibration failed to break up chains in lactose broth cultures of Streptococci and Sarcina Lutea. Addition of 1 p.p.m. of sodium hexametaphosphate 15 min. prior to plating increased count obtained on both vibrated and unvibrated samples, but insufficient no. of expts. conducted to warrant definite conclusions. In one case, which might be considered representative, counts on unvibrated and vibrated raw water were 5,500 and 12,200, respectively. Same water with 1 p.p.m. metaphosphate added gave counts of 9,000 and 17,000 before and after vibration, respectively. Addition of 25 p.p.m. metaphosphate to lactose broth cultures yielded organisms of twice dimensions of those ordinarily obtained. This interpreted as indication that metaphosphate stimulates growth of bacteria. *Discussion. Ibid.* p. 62. Owen Rice: Sodium hexametaphosphate increases bacterial counts obtained on water even when added immediately prior to plating. Effect believed to be due to dispersion of clumps of bacteria. On incubation of cultures containing 25 p.p.m. metaphosphate for 24 hr., at 37°C., some orthophosphate would be formed and principal stimulation to bacterial growth would be due to latter. Jones (Jour. A.W.W.A., **32:** 1471 ('40) ) found that metaphosphate cannot penetrate tissues and membranes, indicating that it cannot be utilized by simple cells, at least not unless it is changed to ortho form. *Ibid.* p. 63. R. B. Adams. Addition of metaphosphate was found to increase decidedly 20° and 37°C. bacterial counts of filtered water.—*R. E. Thompson.*

**Determination and Characterization of Coliform Bacteria From Chlorinated Waters.** Max Levine. Am. J. Pub. Health. **31:** 351 (Apr. '41). Author points out term "coliform organism" might be considered to connote all organisms which resemble *Esch. coli* morphologically and, because of importance in water analysis, question might arise as to whether organisms producing gas only slowly or not at all at 37°C., but vigorously at lower temps. (20° to 30°C.), should be included—in this report, these bacteria included as coliform organisms. Discussion given of differential "Imvic" reactions. Indol test may resume former significance through introduction of tryptophane broth and Goré test and Kovac's reagent making possible detection of indol in 24 hr. instead of 5 days or longer. Tendency of water bacteriol-

ogists to disregard limitations in methyl red reaction as stipulated by Clark and Lubs (carefully stipulated medium and incubation for 5 days at 30°C.) has led to considerable confusion in literature. Numerous cultures observed which were acid to methyl red at 37°C. in 3 or 4 days, but which were alkaline when incubated for same period at 30°C.; other investigators have reported many strains acid at 37°C., but alkaline at 20°C. *Standard Methods* methyl red test after 3 or 4 days at 37°C. is conducive to suppression of no. of methyl red alkaline reactions with result that *Aerobacter* strains are erroneously allocated to *Escherichia* or intermediate section. Because of confusion in literature and frequent disregard of incubation temp. and period, author suggests methyl red differential criterion might well be dispensed with, especially when Voges-Proskauer reaction employed. V.-P. reaction (detn. of presence of acetylmethylcarbinol) particularly important in differentiation of *Aerogenes* from *Escherichia* sections. Observations made on 221 coliform strains to det. effect of temp. and test reagent on V.-P. reactions; test reagents being *Standard Methods* 10% KOH and reagent suggested by Barrett, consisting of 0.6 ml. of 5% alpha naphthol in absolute ethyl alcohol and 0.2 ml. of 40% KOH per ml. of culture medium. Temps. of test reported 37° and 30°C. Noted great many more positive reactions were detected with $\alpha$-naphthol than with KOH, number of positive reactions greater at 30°C. incubation. Indicated $\alpha$-naphthol more delicate indicator for acetylmethylcarbinol than *Standard Methods* technic and difference particularly marked at 37°C.; *Standard Methods* method tends to allocate *Aerobacter* strains to *Escherichia* or Intermediate sections of group. Author's cultures showed no differences in ability to utilize citrate at temps. of 30° and 37°C. Temp. effect noted in various reports in literature during last decade, referring principally to "slow lactose fermenters," or preferably "aberrant" strains. May produce 10% or less gas in 48 hr. at 37°C. in lactose broth and fairly large quantities at lower temps. (20° to 30°C.), and also gas in other presumptive test media. From study of 196 coliform strains from chlorinated water (mostly from unfiltered Lake Michigan supplies), 113 were normal strains and 83 considered "aberrant coliform" bacteria; 15 of these aberrant strains fell into "microaerogenic" category (producing only small amt. of gas in both 37° and 20°. and considered as having san. signif. of true coliform organisms) and 68 produced gas slowly, if at all at 37°, but luxuriantly at 30°C. (considered to be of no san. signif.—"pseudo-microaerogenic" coliform bacilli). 67 of these cultures isolated in summer, only 1 in winter; 30 of 68 allocated to *Aerobacter* section, 27 in Intermediate and 11 in *Escherichia* section. Among 630 standard 10-ml. lactose broth tubes on chlorinated water, 94 positive presumptives were obtained, of which 20 showed gas in B.G.B. and 9 finally confirmed; duplicates of these 630 tubes in tryptose-lauryl-sulfate broth gave only 11 positive presumptives with 10 positive in B.G.B. and in completed test. In these tests, B.G.B. (2%) eliminated large no. of spurious presumptive tests but permitted no. of non-coliform organisms, presumably spore-formers, to grow. Indicated tryptose-lauryl-sulfate broth more dependable; indicated this medium did not eliminate slow lactose fermenters. Peculiar chlorine-resistant organism described, survived 0.5 p.p.m. available Cl dose, killing typical coliform organisms in 10–15 min., for 120 min. Organisms apparently not spore-forming and not unusually heat-resistant. Tryptose-lauryl-sulfate and precautionary measures to assure rapid rise of presumptive test media to 37° considered worthy of careful and sympathetic consideration as procedures for expediting and simplifying bacterial water tests.—*Martin E. Flentje.*

# TITLE 32—NATIONAL DEFENSE

## Chapter IX—Office of Production Management

## Subchapter B—Priorities Division

### *Part 978—Utilities Maintenance, Repair and Supplies*

### PREFERENCE RATING ORDER P-46

978.1 PREFERENCE RATING ORDER. For the purpose of facilitating the acquisition of Material for (1) the maintenance and repair of the property and equipment of the industries and services hereinafter specified, and (2) the operation of such industries and services, a preference rating is hereby assigned to deliveries of such Material upon the terms hereinafter set forth. Such terms shall control until such time as the Office of Production Management certifies specific quantities of such Material to which the preference rating herein assigned may be applied.

(a) *Definitions.*

(1) "Producer" means any individual, partnership, association, corporation, governmental unit or other form of organization engaged in one or more of the following services:

(i) supplying electric power directly or indirectly for general use by the public;

(ii) supplying gas, natural or manufactured, directly or indirectly for general use by the public;

(iii) supplying water directly or indirectly for general use by the public;

(iv) public sanitation services, but not including manufacturers of public sanitation products;

(v) supplying central steam heating directly or indirectly for general use by the public.

(2) "Material" means any commodity, equipment, accessories, parts, assemblies or products of any kind.

(3) "Maintenance" means the up-keep of a Producer's property and equipment in sound working condition.

(4) "Repair" means the restoration of a Producer's property and equipment to a sound working condition after wear and tear,

damage, destruction of parts, or the like, have made such property or equipment unfit or unsafe for service.

(5) "Operating Supplies" means any Material which is essential to the operation of any of the industries or services specified above, and which is generally carried in Producers' stores and charged to operating expense accounts.

(6) The terms "Operating Supplies," "Maintenance," and "Repair" *do not* include Material for

(i) the improvement of a Producer's property or equipment through the replacement of Material which is still usable in the existing installation with Material of a better kind, quality or design;

(ii) additions to, or expansion of, such property or equipment, *other than* the connection of new consumers to the general lowest pressure or lowest potential system of the Producer, and minor improvements needed for relief from serious overload and other minor capital additions;

(iii) expansion of the service area of the Producer.

(7) "Supplier" means any person with whom a purchase order or contract has been placed by a Producer or another Supplier for Material

(i) required by the Producer either as operating supplies or for the maintenance or repair of his property and equipment, or

(ii) to be physically incorporated in other Material so required by the Producer.

(8) "Calendar Quarterly Period" means the quarterly period commencing on the first day of the first, fourth, seventh, and tenth months of the calendar year and ending, respectively, on the last day of the third, sixth, ninth, and twelfth months of the calendar year.

(b) *Assignment of Preference Rating.* Subject to the terms of this Order, Preference Rating A-10 is hereby assigned:

(1) to deliveries, to a Producer, of Material required by him either as Operating Supplies or for the Maintenance or Repair of his property and equipment;

(2) to deliveries, to any Supplier, of Material

(i) required by the Producer either as Operating Supplies or for the Maintenance or Repair of his property and equipment, or

(ii) to be physically incorporated in other Material so required by the Producer.

(c) *Persons Entitled to Apply Preference Rating.* The preference rating hereby assigned may be applied by

(1) a Producer;

(2) any Supplier provided deliveries to a Producer or another Supplier are to be made by him, which are of the kind specified in paragraph (b) and have been rated pursuant to this Order.

(d) *Application of Preference Rating.*

(1) A Producer, before applying the preference rating to deliveries to him, must:

(i) execute duplicate originals of the acceptance attached hereto, certifying that he is entitled to apply the preference rating hereby assigned and agreeing to be bound by the provisions of this Order; and

(ii) file one such executed copy of the acceptance with the Power Branch, Office of Production Management. The Producer shall keep and preserve the other executed copy at his regular place of business for inspection by authorized representatives of the Office of Production Management.

(2) The Producer and each Supplier, in order to apply the preference rating to deliveries to him, must endorse the following statement on the original and all copies of each purchase order or contract for Material, the delivery of which is entitled to the preference rating hereby assigned: "Purchase Order for Utilities Operation, Maintenance and Repair, Preference Rating A-10, pursuant to Preference Rating Order No. P-46," and deliver the original or a copy thereof to the seller of such Material. Such endorsement shall constitute a certification to the Office of Production Management that the Producer or Supplier is entitled to apply the rating to such delivery pursuant to this Order. Such purchase order or contract shall not include any Material the delivery of which is not rated pursuant to this Order.

(3) The Producer or Supplier placing any such rated purchase order or contract and the seller of the Material covered thereby must each retain endorsed copies of all such orders or contracts, segregated from all other purchase orders or contracts, for a period of two years from the date thereof for inspection by authorized representatives of the Office of Production Management.

(4) The Preference rating hereby assigned may be applied to written purchase orders or contracts only.

(e) *Restrictions on Application of Rating.* The preference rating hereby assigned shall not be applied

(1) unless the Material to be delivered cannot be secured when required without such rating;

(2) to obtain deliveries greater in quantity, or on dates earlier, than required for the Operation, Maintenance or Repair of a Producer's property or equipment;

(3) by a Supplier to obtain Material for a delivery by him which has not been rated pursuant to this Order.

(f) *Restrictions on Deliveries, Withdrawals and Inventory.*

(1) No Producer shall, during any Calendar Quarterly Period, accept deliveries (whether or not rated pursuant to this Order) of any items of Material to be used as Operating Supplies or for Maintenance or Repair or any other purpose the aggregate dollar volume of which shall exceed 25% of the aggregate dollar volume of the withdrawals of items of Material of the same class from stores or inventory during the calendar year 1940 unless such deliveries shall be specifically authorized in advance by the Office of Production Management on the Producer's application therefor.

(2) No Producer shall, at any time, accept deliveries (whether or not rated pursuant to this Order) of any item of Material to be used as Operating Supplies or for Maintenance or Repair or any other purpose until the Producer's inventory and stores of items of Material of the same class have been reduced to a practical working minimum, unless such delivery shall be specifically authorized in advance by the Office of Production Management on the Producer's application therefor. Such practical minimum shall in no case exceed the aggregate dollar volume of items of Material of the same class in inventory and stores on December 31, 1940.

(3) No Producer shall, during any Calendar Quarterly Period, make withdrawals from stores or inventory of any items of Material to be used as Operating Supplies or for Maintenance or Repair or for any other purpose the aggregate dollar volume of which shall exceed the aggregate dollar volume of the withdrawals of such items of Material of the same class during the corresponding quarter of 1940, or, at the Producer's option, 25% of the aggregate dollar volume of the withdrawals of such items of Material of the same class during the calendar year 1940 unless such

withdrawals shall be specifically authorized in advance by the Office of Production Management on the Producer's application therefor.

(4) Notwithstanding the provisions contained in paragraphs (f) (1), (2), and (3), a Producer may in any Calendar Quarter increase the aggregate dollar volume of deliveries accepted of Material for use as Operating Supplies, withdrawals of Material for such use, or inventory of Material for such use over the aggregate dollar volume of deliveries, withdrawals or inventory of Operating Supplies during the last preceding corresponding Calendar Quarter proportionately to the increase of the system output in such quarters.

(g) *Audits and Reports*

(1) Each Producer or Supplier who applies the preference rating hereby assigned, and each person who accepts a purchase order or contract for Material to which the preference rating is applied, shall submit from time to time to an audit and inspection by duly authorized representatives of the Office of Production Management.

(2) Each such Producer or Supplier shall execute and file with the Office of Production Management such reports and questionnaires as said Office shall from time to time request. No such reports shall be filed until such time as the proper forms are prescribed by the Office of Production Management.

(3) Until further order each Producer accepting this Order shall, within 30 days after receipt from the Office of Production Management of the acknowledgment of such acceptance, file with the Office of Production Management a certified report in the form accompanying such acknowledgment.

(4) Each Producer shall maintain a continuing inventory of Material included in stores accounts.

(h) *False Statements and Penalties.* Any person who applies the preference rating hereby assigned in willful violation of the terms and provisions of this Order or willfully falsifies any records which he is required to keep by this Order, or who obtains a delivery of Material by means of a material and willful misstatement will be forbidden to further apply said rating. Such person may also be prohibited from obtaining further deliveries of Material under allocation and be deprived of any other priorities assistance. The Director of Priorities may also take any other action deemed appropriate, including the making of a recommendation for prosecution under section 35A of the Criminal Code (18 U.S.C. 80).

(i) *Revocation or Modification.* This Order may be revoked or amended by the Director of Priorities at any time as to any Producer or Supplier. In the event of revocation, or upon expiration of this Order, deliveries already rated pursuant to this Order shall be completed in accordance with said rating, unless the rating has been specifically revoked with respect thereto. No additional applications of this rating to any other deliveries shall thereafter be made by the Producer or Supplier affected by said revocation or expiration.

(j) *Effective Date.* This Order shall take effect immediately, and unless sooner revoked shall expire on the 31st day of March, 1942.

(P.D. Reg. 1, Aug. 27, 1941, 6 F. R. 4489; OPM Reg. 3, March 8, 1941, 6 F. R. 1596; E. O. 8629, Jan. 7, 1941, 6 F. R. 191; E. O. 8875, Aug. 28, 1941, 6 F. R. 4483; sec. 2 (a), Public No. 671, 76th Congress, Third Session, as amended by Public No. 89, 77th Congress, First Session; sec. 9, Public No. 783, 76th Congress, Third Session.)

Issued this 17th day of September, 1941.

DONALD M. NELSON
*Director of Priorities*

[The Definition of the word "Producer" under Paragraph (a) should be carefully noted by the reader. It is also to be noted that two exact copies of the Acceptance Form are to be made, one retained by the Producer and one sent to the Power Branch, Office of Production Management, Washington, D. C.]

Director of Priorities Nelson issued on September 23 an official interpretation of Sec. 978.1 which contains the following information:

"Section 978.1 permits the application of the preference rating therein assigned to purchase orders of Material for maintenance, repair or operating supplies placed by a Producer prior to the effective date of such Preference Rating Order. The preference rating assigned may be applied to such purchase orders by filing with the Supplier of the Material a duplicate copy of the purchase order theretofore placed, endorsed in the manner specified in Paragraph (d) of the Order."

## Acceptance of Preference Rating Order No. P-46

*To Be Signed by a Principal Officer of the Producer Before Applying the Preference Rating Assigned by Preference Rating Order P-46*

The undersigned certifies to the Director of Priorities of the Office of Production Management that he is engaged in the following industry or service:

and is therefore a Producer entitled to apply the preference rating assigned under Preference Rating Order No. P-46, issued by the Division of Priorities, Office of Production Management, in accordance with the definition of "Producer" therein contained and the other terms thereof; that he has read the Order, and hereby agrees to be bound by all the terms and conditions thereof.

Dated this ............... day of ............................, 1941.

..............................................................
Legal Name of Producer

By: ..............................................................
Principal Officer (President, Vice President, or other Corresponding Official)

..............................................................
Address

*Instructions*

The Producer shall insert the classification of Producer, as defined, to which he belongs, execute one copy of this Acceptance and send it to the Power Branch, Office of Production Management, Washington, D. C., and shall execute and retain a second copy as specified in Preference Rating Order P-46. No Supplier shall execute this Acceptance.

Section 35A of the Criminal Code, 18 U.S.C. 80, makes it a criminal offense to make a false statement or representation to any Department or Agency of the United States as to any matter within its jurisdiction.

# Tentative Standard Specifications for Sluice Gates

Approved as Tentative Specifications by the A. W. W. A. Board of Directors on June 26, 1941

## Table of Contents



## Section 1—Type of Gate and Character of Service

1.01 These specifications cover sluice gates for water works service under the following classifications:

*By type of opening*—round, rectangular, square;

*By stem movement*—rising stem, non-rising stem;

*By direction of pressure*—seating pressure, unseating pressure;

*By type of end connection*—spigot end, flange end, flange and spigot, flat frame, flat frame and spigot;

*By type of operating mechanism*—hand operated, hydraulically operated, electrically operated.

1.02 These specifications are intended for general use only and for sizes up to 36 inches by 36 inches and operating heads not exceeding 75 feet, and for sizes larger than 36 inches by 36 inches up to and including 96 inches by 96 inches for operating heads not exceeding 50 feet. They do not cover special conditions, which require special study and design, such as greater operating heads, unusually corrosive water, continual service in a throttled position, and the like.

1.03 Where conditions are such that special study and design are necessary, these specifications may be used as far as they apply, beyond which design and construction are to be a matter of negotiation and specification between purchaser and manufacturer.

## Section 2—Supplementary Details to Be Specified

2.01 In using these specifications, it will be necessary for the purchaser to supplement them with specific requirements for each gate, as follows:

Size and shape of opening
Stem, rising or non-rising
Method of operation
Length of stem
Appurtenances, such as wall castings, anchor bolts, guide brackets, etc.
Special bronze mounting
Drawings required
Type of frame, flanged or spigot
Pressure, amount and direction
Operating stem material and extension stem material
Direction of stem rotation to open
Special markings
Special tests required

## Section 3—Data to Be Furnished by Manufacturer

3.01 In advance of construction the manufacturer shall furnish catalog data, including illustrations and schedule of parts and the materials of which they are made, in sufficient detail to serve as a guide in the assembly and taking down of the gate and in ordering repair parts.

3.02 When required by supplementary specifications, the manufacturer shall furnish a statement giving the total net assembled weight of each size of gate, and when required shall furnish drawings of adequate size showing the principal dimensions, kind of material and finish to all parts.

### Section 4—Size of Waterway

4.01 With the gate in full open position, each gate shall have an unobstructed waterway opening of net area equal to the size sluice gate called for.

### Section 5—Basis of Structural Design

5.01 All parts of all sluice gates shall be designed to withstand with factors of safety of not less than five, all test and service stresses without permanent distortion of any parts or part.

### Section 6—Iron Castings

6.01 In general, all sluice gate parts except seat faces, wedges, stems and shafts, and some miscellaneous trim, are to be cast from a superior quality of iron, remelted in a cupola, or in an air or electric furnace, producing a metal which is tough, or of uniform fine grain, without chilled surfaces, readily machined, and conforming with the standard specifications of the American Society for Testing Materials, Serial Designation A-126-30, Class B, or the latest revision thereof. Metal thickness as shown on the drawings for castings shall be considered minimum. All castings shall be clean and sound without defect of any kind; no plugging, welding or repairing of defects shall be allowed.

6.02 From each heat of metal the manufacturer shall make and test without charge, two flexure, and two tension test bars. Certified copies of these tests shall be furnished the purchaser if requested.

### Section 7—Bronze

7.01 All sluice gate parts requiring special ability to resist corrosion or requiring surfaces to minimize friction shall be made of bronze, or faced with bronze or with other suitable and approved non-corrodible metal.

7.02 All parts of bronze or other non-corrodible metal, such as wedges, stem, stem nut, and facings, shall be the best of their kind and best suited to their function in service, and shall be agreed upon by the purchaser and manufacturer as to physical properties before being used, if required by the purchaser.

Metal for parts where strength and resistance to wear are needed, such as stem, stem nuts, couplings, thrust nuts, etc., shall have a tensile strength of not less than 60,000 pounds per square inch.

Metal for wedges, wedge seats, and other parts except facings shall have a tensile strength of not less than 30,000 pounds per square inch.

Metal for facings shall be sufficiently malleable to conform to and completely fill the grooves in the disc and frame and shall have a minimum compressive strength, without deformation, of 4,000 pounds per square inch.

If required, the manufacturer shall make and submit to the purchaser, without charge, such analyses and tests as will demonstrate the compliance of each kind of non-corrodible metal with the above provision.

### Section 8—Bolts, Studs and Nuts

8.01 All bolts, studs and nuts shall be American Standard regular and except as otherwise specified shall be made of steel conforming with the Standard Specifications of the American Society for Testing Materials, Serial Designation A-107-36 for carbon open hearth hot rolled bar steel. They shall be rust proofed by an approved process. Or they may be of "Everdur" or other high tensile strength corrosion-resistant metal.

8.02 Bolt heads and nuts shall be "semi finished" when bearing is on finished surfaces.

### Section 9—Type of End Connections

9.01 Sluice gates shall be made with either spigot or flanged ends.

9.02 Spigot ends shall conform to the dimensions shown on the manufacturers drawings.

9.03 Flanged ends shall conform to the dimensions shown on the manufacturers drawings.

9.04 Wall thimbles, if required, shall be of cast iron of the same quality as that used in the gate, and shall have one end flanged to match the flange of the gate frame to which it is to be attached. The other end may be spigot, flanged or bell as the conditions of construction demand.

### Section 10—Frames

10.01 The frame shall be of cast iron of ample section and shall be cast in one piece. All surfaces forming joints or bearings shall be machined.

10.02 The frame may be of the flat type, may be cast integral with a spigot end for imbedding in masonry, or may be cast with a flange end for attaching to masonry or to a wall thimble.

## Section 11—Disc

11.01 The disc shall be of cast iron with stiffening ribs and with a reinforced section around the rim opposite the gate facings. The disc shall have tongues on each side extending the full length of the disc and these tongues shall be accurately machined all over. Surfaces of the disc which come in contact with the seat facings, and wedges shall be accurately machined. A socket shall be provided above the horizontal center line of the gate, heavily reinforced by ribs, into which shall be fitted a one piece nut of non-corrodible metal, threaded and keyed or pinned to the stem in the case of rising stem sluice gates, and threaded in the case of non-rising stem sluice gates. Threaded nuts shall be prevented from turning during the operation of the gate.

## Section 12—Face Rings or Facings

12.01 Strips of non-corrodible metal shall be firmly secured in finished grooves in the frame and disc. These facings shall be of ample section and so finished by machine and hand work after placement, that with the gate assembled with the disc in a closed position, the facings will be in such intimate contact one with the other, and with the facing grooves, that a water tight joint will be formed between them at each and every point in their perimeter.

12.02 The method of attaching the facings to the disc and to the frame shall be subject to the approval of the purchaser, and the chosen method shall be so well carried out that the finished facings will remain in place, free from distortion or loosening, during the effective life of the sluice gate.

## Section 13—Wedging Devices

13.01 Unless otherwise specified, all sluice gates shall be equipped with suitable wedging devices so designed and constructed that they will effectively cause full, complete and water tight contact between disc and frame facings on closure of the gate. Wedging devices shall be of non-corrodible metal, or with all bearing surfaces faced with non-corrodible metal. Wedges shall be so designed that they can be easily adjusted and yet will remain fixed after being properly adjusted. Fastenings of wedges to gate may be rust-proofed steel, but all adjusting mechanism shall be of non-corrodible metal.

In addition to side wedges, top and bottom wedges shall be furnished on all sluice gates 20 inches and larger in width subject to unseating pressures.

### Section 14—Guides

14.01 Guides unless cast integral with the frame shall be heavily bolted to the frame, and provision shall be made to prevent lateral movement by the use of: either tongues and grooves, keys and key ways, shoulders or lugs.

The guides shall be reinforced with heavy ribs at points of contact with the side wedges of the disc, capable of taking the whole thrust due to water pressure and wedging action.

Wedge facings shall be attached to the guides where necessary and these wedge facings shall be machined on all bearing surfaces and shall make accurate contact with the side wedges.

14.02 For non-rising stem gates of the self-contained type, the guides shall be joined at the top by a thrust yoke and both guides and yoke shall be designed with safety factor the same as stated in Sect. 5.01.

### Section 15—Stems

15.01 The operating stem shall be of a size to withstand safely, without buckling or permanent distortion, all stresses, either compression, tension or torsion, to which it may be subjected in the installation in which it is to be used.

The screw sections of the stem shall have machine cut threads, square or Acme Standard, and the number of threads per inch shall be such as to work most efficiently with the operating mechanism to be used (see types of operating mechanism under Sect. 1.01).

The threaded portion of the stem, if designed to operate under water, shall be of non-corrodible metal. Extension stems or stems not operating under water may be of such metal as specified by the purchaser, after demonstration by the manufacturer of compliance of the metal used with that specified.

15.02 Where stems or shafts are furnished in more than one piece, the different sections shall be joined together by solid couplings of non-corrodible metal, threaded and keyed.

### Section 16—Wall Guides and Bearings

16.01 Wall guides, brackets and bearings shall be of rugged construction to hold stems and shafts in true line, and shall be spaced at such intervals, not over 12 feet, as will assure that alignment will

be maintained and yet free enough to permit easy operation. Bearings shall be lined with non-corrodible metal, shall be adjustable with respect to the bracket in two directions horizontally and shall be so designed that alignment will be maintained indefinitely after adjustment.

16.02 Brackets shall be rigidly attached to walls in a manner that will hold the guides or bearings in place at all times, the attaching bolts or studs being either of a material or so protected that they will not corrode.

## Section 17—Thrust Bearings

17.01 Bearings to take thrust shall be provided in the yoke for gates with non-rising stems of self contained type and in the operating stand for all other gates with rising stem. These shall be designed to develop safely the full strength of the stem or shaft, and the housing for the bearing shall be carefully machined. Bearings shall operate bronze to iron, or shall be roller or ball bearing.

## Section 18—Operating Mechanism

18.01 Sluice gates may be operated by hand power, hydraulic power or electric power. For gates with non-rising stem, a strong rugged mechanism shall be provided which will efficiently transmit power to rotate the stem and shaft in either direction. For gates with rising stem, in addition to a strong rugged mechanism, a nut with suitable physical properties shall engage with the thread of the stem, and be rotated by power to raise or lower the disc.

18.02 Operating stands shall be of cast iron, of sturdy design, with adequate provision for bolting to the operating floor, and with ample strength in all parts to resist the stresses experienced in service. Gears shall be of cast iron, steel or bronze, accurately formed and smooth running with suitable shafts running in bronze or babbit lined bearings of ample size. For special conditions, or if specified, ball or roller bearings may be substituted for plain bearings in all or part of the mechanism, and metal other than cast iron may be used for superior service in pinions, worms, shafts or other parts.

18.03 Hydraulic cylinders shall be arranged to apply power up and power down and if specified a device shall be provided to lock the gate in the fully open position. Provision for the attachment of hoisting equipment to raise the gate in case of failure of the hydraulic power must be provided.

18.04 Gate stands operated by electric power shall be equipped with motors of proper size and type for the current available and

the service intended, including limit switch. All electrical work shall conform to the National Electric Code, and local requirements. Gates are to be operated under power both up and down, and in case of power failure provision shall be made for operating the gates by hand with the motor mechanically disconnected from the hand operated mechanism.

### Section 19—Indicators

19.01 If specified by the purchaser, sluice gates with non-rising stems shall have indicators attached, which will show accurately the position of the gate when operating with relation to its port or opening.

### Section 20—Workmanship

20.01 All foundry and machine work shall be done in accordance with the best modern practice for the class of work involved. All parts entering into the sluice gates and stands shall be carefully and accurately machined to jigs and templates and all like parts shall be absolutely interchangeable so that repair parts can be furnished at any time and can be attached in the field without any fitting, chipping or re-machining.

20.02 All parts shall conform accurately to the required dimensions, and shall be free from injurious defects. Anchor bolt holes shall be drilled accurately to template to the layout called for on the drawings.

20.03 All joints shall be faced true and shall be water tight where subjected to water pressure.

20.04 All iron parts receiving bronze mounting shall be finished to fit.

20.05 After the parts have been accurately machined, each gate shall be assembled completely in the shop and there shall be no fitting or departure from the dimensions on the shop drawings to make the different parts fit properly together. A neat, workmanlike, well fitting and smoothly operating job throughout shall be produced with all like parts interchangeable.

### Section 21—Painting

21.01 All iron parts of the sluice gates and stands, except finished or bearing surfaces shall be painted in such manner and with such materials as well inhibit rusting for the longest possible period. The manufacturer shall select the method and material to accomplish the purpose, subject to the approval of the purchaser. At least two coats of paint shall be applied to each part before assembly and test-

ing. The final coat or coats shall be applied to the exterior surfaces after assembling and testing.

### Section 22—Testing

22.01 After completion each sluice gate shall be tested in the shop for performance in operation including that of the hydraulic cylinders, motors or hand operating mechanism.

### Section 23—Inspection

23.01 All work under these specifications shall be subject to inspection and approval by the purchaser or his agent, who shall at all times have access to all places of manufacture, where materials are being produced or fabricated, or where tests are being conducted, and shall be accorded full facilities for inspection and the observation of tests. Any sluice gate or part which may be condemned as not conforming to the requirements of these specifications shall be made satisfactory or shall be rejected and replaced.

### Section 24—Preparing for Shipment

24.01 Sluice gates shall be complete when shipped, and the manufacturer shall use all due and customary care in preparing them for shipment so as to avoid damage in handling or in transit. Particular care shall be taken to see that all gates are completely closed before shipment, and all finished and bearing surfaces grease slushed.

Sluice gates, especially those 24 inches and larger, shall be securely bolted or fastened to skids in such a manner that they may be safely unloaded either by hand or crane.

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### Personnel of Committee 7F

(On Valves, Sluice Gates and Fire Hydrants)

WM. R. CONARD, *Chairman*
WM. FLANNERY
HAROLD W. GRISWOLD
J. ARTHUR JENSEN
FRANK H. STEPHENSON

**APPLICATION FOR MEMBERSHIP**
**IN THE**
**AMERICAN WATER WORKS ASSOCIATION**
**22 EAST 40th ST., NEW YORK**

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Date:..............................................

........................ hereby make application for
(I or We)

.......................................................................................................
(Active, Junior, Corporate or Associate Membership, or Affiliate)

in the American Water Works Association, and enclose herewith the sum of $........................, one year's dues in advance.

Name.......................................................................................

Company or Department.......................................................................

Title or Position...........................................................................

Address.....................................................................................

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If application is for Junior Membership, give date of birth.........................

If application is for Affiliate, state number of active services in property where employed.......................................................................

Nature of business or character of work (for office records).......................

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If application is for Corporate or Associate Membership, it must be signed by the person designated to represent the firm or corporation in A.W.W.A. activities.

.............................................................
Signature of Applicant.

Application obtained by:

.......................................................................................................

(over)

## ARTICLE I OF BY-LAWS

Section 3. An Active Member shall be a superintendent, a manager, an official or employee of a municipal or private water works; a civil, mechanical, hydraulic, or sanitary engineer, a chemist, a bacteriologist, or any qualified person engaged or interested in the advancement of knowledge relating to water supplies. (Annual Dues, $10.00.)

Section 4. A Corporate Member shall be a Water Board, Water Commission, Water Department, Water Company or Corporation, National, State or District Board of Health, or other body, corporation or organization engaged or interested in water supply work, and shall be entitled to one representative whose name shall appear on the roll of members, and who shall have all the rights and privileges of an Active Member. This representative may be changed at the convenience and pleasure of the Corporate Member on written notice to the Secretary. (Annual Dues, $15.00.)

Section 5. An Associate Member shall be either a person, firm or corporation engaged in manufacturing or furnishing supplies for the operation, construction, or maintenance of water works. (Annual Dues, $25.00.)

Section 6. A Junior Member shall be an employee of a municipal or private water works; a civil, mechanical, hydraulic, or sanitary engineer, a chemist, a bacteriologist, a student or any otherwise qualified person engaged or interested in the advancement of knowledge relating to water supplies. At the time of his admission he shall be not less than eighteen years of age. His connection with the Association shall cease when he becomes twenty-five years of age, unless he is regularly enrolled as a student in a university or has previously transferred to the grade of Active Member. Junior Members ahall receive the Journal and all privileges of Active membership except holding office and voting. (Annual Dues, $5.00.)

Section 7. An Affiliate shall be any person otherwise qualified for Active membership who, at the time of application, is not nor previously has been a member of the Association and who, for acceptable reasons, does not wish to become an Active Member.

No corporation, firm or partnership which otherwise would be entitled to the grades of Associate or Corporate member may hold the grade of Affiliate. No employee of an Associate member may become an Affiliate. No person who is the superintendent, the manager, the chief engineer, the superintendent of filtration, the chief chemist, or the superintendent of distribution in a plant having more than 3,000 active services, is eligible for the grade of Affiliate. Under unusual conditions, exception to the above may be made by action of the Executive Committee if the applicant sets forth fully the reasons for the exception when applying for the Affiliate grade.

Affiliates shall not be entitled to vote upon general Association questions, and not eligible to hold office in the Association, nor in any of its Divisions. They shall be eligible to vote upon Section questions and to hold Section offices except those of Chairman, Vice-Chairman, Secretary (and/or Treasurer). They shall be entitled to all other rights and privileges of Active Members. Affiliates receive the March, June, September and December issues of the Journal each year. (Annual Dues, $4.00.)

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Memberships will be dated as of the beginning of the quarter in which the application is received.

Membership in the Association carries, also with no additional dues, membership in its Local Sections and National Divisions, and includes the Journal, a monthly publication devoted to water works interest. The proceedings of the annual conventions and of the meetings of the Local Sections are published in the Journal, which also contains contributed articles on subjects pertaining to public water supplies.